Underground Mining of Metalliferous Deposits
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Lecture 11
Recovery

MINERAL RESOURCES AND RESERVES

- *Mineral resources* is the name given to minerals which contain elements such as gold, silver, copper, lead, zinc, iron, aluminum, nickel, molybdenum etc., as well as fossil fuels, like oil, natural gas, and coal.

- *Mineral reserves* are concentrations of various minerals and it is a geological term. Whether a mineral deposit is also an ore deposit depends on its economic value.
- Geologists distinguish between mineral resources and reserves. The term resource refers to hypothetical and speculative, undiscovered, sub-economic mineral deposits or an undiscovered deposit of unknown economics.
- Reserves are concentrations of a usable mineral or energy commodity, which can be economically and legally extracted at the time of evaluation.
- "Ore deposit" is therefore an economic term of a mineral deposit.

Identified (Mineral) Resource: Are the specific bodies of mineral-bearing material whose location, quantity, and quality are known from specific measurements or estimates from geological evidence. Identified resources include economic and sub-economic components.

To reflect degrees of geological assurance, identified resources can be divided into the following categories:

- ❑ **Measured:** Are the resources for which tonnage is computed from dimensions revealed in outcrops, trenches, workings, and drill holes, and for which the grade is computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are spaced so closely, and the geological character is so well defined, that size, shape, and mineral content are well established.
- ❑ **Indicated:** Are the resources for which tonnage and grade is computed from information similar to that used for measured resources, but the sites for inspection, sampling, and measurement are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than for resources in the measured category, is high enough to

assume continuity between points of observation. *Demonstrated: A collective term for the sum of measured and indicated resources.*

- ❑ **Inferred:** Are the resources for which quantitative estimates are based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition for which there is geological evidence. This evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included if there is specific geological evidence of their presence.

RECOVERY

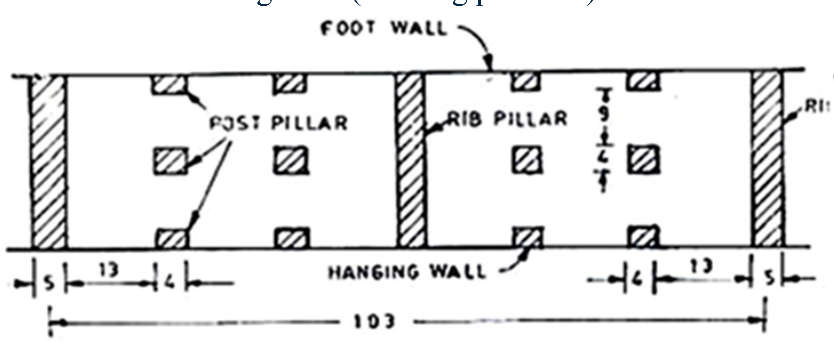
Ore recovery is based on the material within the working model that is left behind to provide structural support or not recovered due to geological disturbances.
The generalized equation for recovery is given below:

$$\text{Recovery}(\%) = \frac{\textit{Extracted ore}}{\textit{Extracted ore} + \textit{Unexracted ore}}$$

$$\frac{\textit{Extracted ore}}{\textit{Extracted ore} + \textit{Unexracted ore}} \times 100$$

It can be computed with respect to a stope, a larger mineral block or a whole mine.
It can also be specific to a method of working.

- Sometimes switching over to highly mechanized method from labour intensive method may lead to less recovery.
- In practice Recovery in a mine is affected by the followings:
    - Ore left in the Sill and crown pillars
    - Ore left in the Rib pillars between stopes
    - Ore left in the ore-backfill contact
    - Ore lost in the tailing floor (working platform)



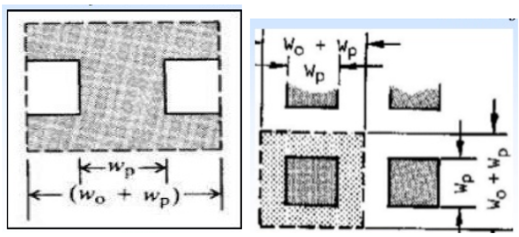
PLAN OF THE STOPE FLOOR

Room and Pillar Example:

Viewing a room and pillar operation from a longitudinal cross section, given the width of the pillar (w_p) and the width of the opening (w_o) the recovery is given by the following equation:

$$Recovery(\%) = \frac{w_o}{w_o+wp}\,\frac{w_o}{w_o+wp} \times 100$$

Room and Pillar: Longitudinal section



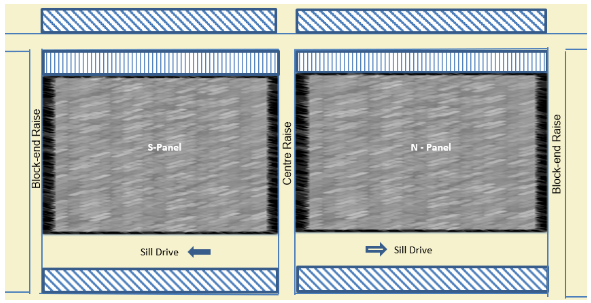
Room and Pillar: Longitudinal section and plan view

Viewing a room and pillar operation from a PLAN VIEW, given the width of the pillar (w_p) and the width of the opening (w_o) the recovery is estimated as follows:

$$Recovery(\%) = \frac{((w_o + w_p)^2) - (w_p)^2}{(w_o + w_p)^2} * 100\%$$

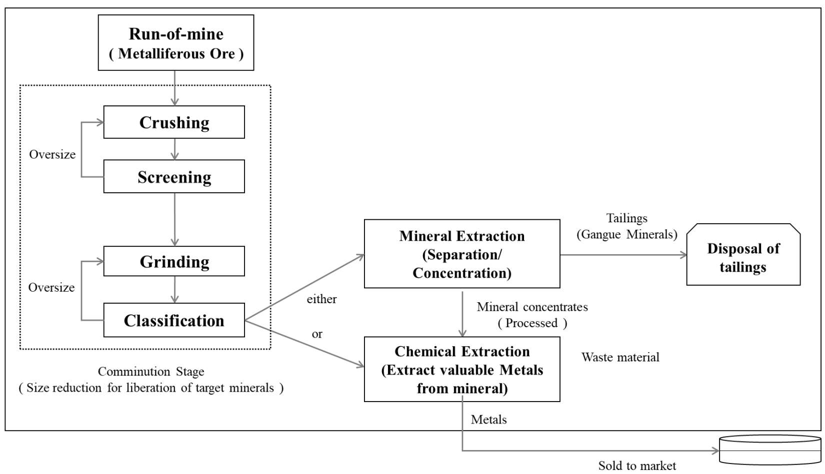
RECOVERY in POST PILLAR METHOD

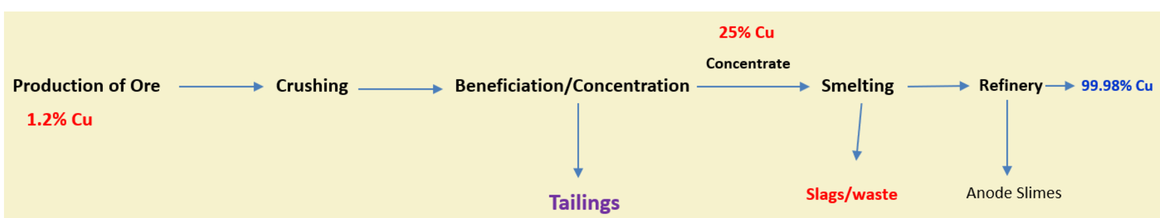
- Depending on the mining method being used, Recovery can be estimated by understanding the stope dimensions an design relative to the mineralization.
- Sometimes huge ore is left as protective shaft pillars if it is passing through mineralization (lode)
- In case we forcibly try to increase RECOVERY, it may lead to increased DILUTION.
- In certain cases, Recovery can be increased by Double Lift mining (say in Cut and Fill Stope)



Longitudnal section projected on vertical plane

RECOVERY IN MINERAL and METALLURGICAL PROCESSING





(Fine Waste + Trace value minerals)

Enrichment ratio: The enrichment ratio is calculated by dividing the concentrate assay by the feed assay as follows: enrichment ratio = 25.00/1.20 = 20.83.
This reveals that the concentrate has 20.83 times the copper concentration of the feed.

- **Metal in Ore (MIO)**
- **Metal in Concentrate (MIC)**
- **Metal content in final product**

Problem:
An underground copper mine produces 5500 tons per day @1.2% Cu as grade.
The ore is sent to a crusher and concentrator plant which uses froth floatation process with a metal recovery of 93%. The concentrate produced has 26% Cu grade.
Find out for 25 working days/month: i) Metal in Ore, ii) Metal in concentrate, iii) Quantity of concentrate produced per month, iv) Quantity of tailings as mill reject and v) percentage of residual Cu in mill tailings.
Solution:
An underground copper mine produces 5500 tons per day @1.2% Cu as grade.

First, **Metal in Ore (MIO)**

$5500 \times (1.2/100) \times 25 = 66 \times 25 = 1650$ t of Cu in ROM
The ore is sent to a crusher and concentrator plant which uses froth floatation process with a metal recovery of 93%. The concentrate produced has 26% Cu grade.

Next, **Metal in Concentrate (MIC)**

The ore is sent to a crusher and concentrator plant which uses froth floatation process with a metal recovery of 93%. The concentrate produced has 26% Cu grade.

Given , MIO = 1650 t and recovery in processing = 93%
So, MIC = $1650 \times 0.93 = 1534.50$ t

Next: **Quantity of concentrate produced per month**

The ore is sent to a crusher and concentrator plant which uses froth floatation process with a metal recovery of 93%. The concentrate produced has 26% Cu grade.

Given , MIC = $1650 \times 0.93 = 1534.50$ t, Concentrate Grade = 26% Cu
So, amount of concentrate produced = $1534.50/0.26 = 5901.92 \sim 5902$ t
Tailings rejected = $(5500 \times 25) – 5902 = 1,31,598$ t

Next: Cu percentage in Mill rejects (tailings)

Given , MIC = 1650
MIC = 1534.50 t
Tailings rejected (Q_t)= $(5500 \times 25) – 5902 = 1,31,598$ t
Copper lost in tailings = MIO – MIC = 1650 - 1534.50 = 115.50 t
Grade (%) = $[(MIO – MIC)/Q_t] \times 100 = 0.088\%$ [Cu percent in Mill Tailings)