Underground Mining of Metalliferous Deposits
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Lecture 26
Selection of Mining Methods-1

METHOD SELECTION- OVERVIEW

The optimum mining method:

- ❑ Maximizes the economic returns while keeping the environmental impact within acceptable levels.
- ❑ Maintains acceptable work conditions:
    - i. *Safety of employees.*
    - ii. *Satisfy statutory obligations (including resource recovery stipulations).*
- ❑ Ensure conservation of minerals

Collectively, these goals will also satisfy the objective of efficient use of the mineral resource.

KEY INFLUENCES ON SELECTION OF MINING METHOD

- ❖ **Style of Mineralization**
- ❖ **Strength and Character of the Rock Mass**

- The shape size and regularity of the deposit.
- Mineralogical character, value of ore and the distribution of values.
- The dip, width and strength of ore.
- The character of walls.
- Ease with which ore separates from walls.
- Continuity of roe with the boundaries of deposit.
- The cost and availability of support material.
- Depth below the surface and nature of overburden.

- Output desired and extent of mechanization planned for stoping within the financial resource available.
- Possibility of dilution of ore with waste.
- Surface features.

1. Style of Mineralization:

- Range of geometric attributes and mechanisms that control and determine the distribution of valuable minerals within the deposit.
- Use of mine planning software packages for three-dimensional (3-D) visualization, wireframe triangulation facilities, and block modeling systems.
- These tools have the facility for preparing long sections illustrating grade isopachs, thickness isopachs, and structurally controlled grade trends.
- Example: Geological data (drill-hole sampling) of a steeply dipping, tabular gold deposit substantially affected by faulting, folding, or shearing and displaying pronounced grade trends require a wider range of possible mining methods to be considered.
- Mineral resource models that reflect the inherent uncertainties provide enhanced assistance for the optimum selection of a mining method.

2. Strength and Character of the Rock Mass

- Any process intended to aid the selection of an excavation method must consider the strength and character of the host rock mass.
- Determination of representative mechanical properties of the host rock mass.
- Empirical rock mass classification methods.
- Requires detailed information on in-situ stresses, rock mass properties, and planned excavation sequence.

Empirical rock mass classification methods

Terzaghi's rock mass classification.

- The earliest reference to the use of rock mass classification for the design of tunnel support.
- The rock loads, carried by steel sets, are estimated on the basis of a descriptive classification.
- Draws attention to those characteristics that dominate rock mass behavior, particularly in situations where gravity constitutes the dominant driving force.
- Example descriptions (quoted directly from his paper):

  Intact rock contains neither joints nor hair cracks. Because of injury to the rock due to blasting, spalls may drop off the roof several hours or days after blasting—known as a spalling condition.

  Hard, intact rock may also be encountered in the popping condition involving the spontaneous and violent detachment of rock slabs from the sides or roof etc.

Rock quality designation (RQD)

- The RQD index provides a quantitative estimate of rock mass quality from drill core logs
- RQD is a directionally dependent parameter, and its value may change significantly, depending upon the borehole orientation. (Deere et al.,1967)

$$RQD = \frac{\sum Length\ of\ \ Core\ Pieces\ > 10\ cm\ Length}{Total\ Length\ of\ \ Core\ Run} \times 100$$

RQD Rock Mass Classification	
Excellent	≥90%–100%
Good	≥75%–90%

Fair	≥50%–75%
Poor	≥25%–50%
Worse	≤25%

Rock mass rating (RMR)

The following six parameters (addition) are used to classify a rock mass using the RMR system:

1. Uniaxial compressive strength of rock material (UCS in MPa)

2. RQD

3. Spacing of discontinuities*

4. Condition of discontinuities (separation or aperture of Discontinuities)

5. Groundwater conditions (influence of groundwater pressure or flow on the stability of underground excavations)

6. [Orientation of discontinuities]- adjustment

RMR	**Rock quality**
0-20	Very Poor
21-40	Poor
41-60	Fair
61-80	Good

81-100	Very good

*Spacing is the perpendicular distance between adjacent discontinuities, and is usually expressed as the mean spacing of a particular set of joints. The spacing of discontinuities determines the sizes of the blocks making up the rock mass.

Modified rock mass rating (MRMR)

- This system takes the basic RMR value, as defined by Bieniawski, and adjusts it to account for in-situ and induced stresses, stress changes, and the effects of blasting and weathering.
- Main emphasis is on cavability
- A set of support recommendations is associated with the resulting MRMR value.
- The selection process is based on his rock mass classification system, which adjusts for expected mining effects on the rock mass strength.
- The two parameters that determine whether a caving system is used over a stoping system are the degree of fracturing, RQD, joint spacing, and the joint rating, which is a description of the character of the joint—that is, waviness, filling, and water conditions. This scheme puts emphasis on the jointing as the only control for determining cavability.

Rock tunneling quality index (Q)

- Rock tunneling quality index (Q) for the determination of rock mass characteristics and tunnel support requirements. (Barton et al. 1974)
- The numerical value of Q varies on a logarithmic scale from 0.001 to a maximum of 1,000

$$Q = \frac{RQD}{Jn} \times \frac{Jr}{Ja} \times \frac{Jw}{SRF}$$

where,

RQD = rock quality designation

J_n = joint set number

J_r = joint roughness number*

J_a = joint alteration number

J_w = joint water reduction factor

SRF = stress reduction factor**

MINING METHOD SELECTION AND EVALUATION METHODOLOGIES

- The method selection process should first determine whether the deposit should be mined using a more traditional surface, underground, or in-situ leach mining method.
- A novel method should only be considered if traditional methods are not *economically or technically feasible*.