Underground Mining of Metalliferous Deposits

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Lecture 30
Selection of Mining Methods-V

Mining Methods

University of British Columbia (UBC) method by Miller-Tait et al (1995)*

- ➢ An empirically derived modification to the Nicholas 1981 method to determine the method of working for Underground mining.
- ➢ The UBC method is similar to the Nicholas method in both approaches i.e.
- Geometry/Grade Distribution of the deposit
- Rock mechanics characteristics.
- ➢ However the UBC method has modified characteristics of both these parameters.
- ➢ This is based on:
- Improved rock support techniques
- More technical oversight of production
- Increased size and sophistication of mechanical equipment.

Modifications in UBC method:

For ore width:

- A **very narrow** category i.e <3m in thickness was added to account for narrow vein mining.
- This applies a discount to the option of using an open stoping method due to dilution control issues.
- Manual mining methods using jacklegs or stopers are given preference.

Ore Thickness

i. Very Narrow: <3m
ii. Narrow: 3-10m

iii. Intermediate 10m – 30m

iv. Thick: 20m – 100m

v. Very Thick: >100m

Rock mechanics rating:

- Bieniawski 1976 **Rock Mass Rating** system replaces rock mechanics characterisation for fracture spacing and fracture shear strength.
- Takes advantage of the universal use of the Rock Mass Rating for consistency of data analysis.

Rock Mass Ratings (Bieniawski 1976)

- Very Weak: 0-20
- Weak: 20-40
- Moderate: 40-60
- Strong: 60-80
- Very Strong: 80-100

The rock substance strength is modified to account for the maximum in situ stress instead of the overburden pressure.

For eg: Horizontal stresses in Canadian mines were found to be two or more times the overburden pressure.

Rock Substance Strength :(Uniaxial strength/maximum principal stress)

- Very Weak: <5
- Weak: 5-10
- Moderate: 10-15
- Strong: >15

Conditions where it would be unsafe for manned entry without ground support.

The UBC Mining Method Selection process is as follows:

1. **General Shape**

    i. Equi-dimensional: all dimensions are on the same order of magnitude

    ii. Platety-tabular: two dimensions are many times the thickness, which does not usually exceed 35m

iii. Irregular: dimensions vary over short distances.

2. **Ore Thickness**

i. Very Narrow: <3m

ii. Narrow: 3-10m

iii. Intermediate 10m – 30m

iv. Thick: 20m – 100m

v. Very Thick: >100m

3) Plunge

- Flat: <20º
- Intermediate: 20º - 55º
- Steep: >55º

4) Depth below surface

- Shallow :0-100m
- Intermediate : 100-600m
- Deep :>600m

5) **Grade Distribution**

1. **Uniform**: the grade at any point in the deposit does not vary significantly from the mean grade for the deposit.
2. **Gradational**: grade values have zonal characteristics, and the grades change gradually from one to another.
3. **Erratic**: grade values change radically over short distances and do not exhibit any discernible pattern in their changes.

6) **Rock Mass Ratings** (Bieniawski 1976)

- Very Weak: 0-20
- Weak: 20-40
- Moderate: 40-60
- Strong: 60-80
- Very Strong: 80-100

7) **Rock Substance Strength** (Uniaxial strength/maximum principal stress)

- Very Weak: <5
- Weak: 5-10
- Moderate: 10-15
- Strong: >15

Table No 1. Geometry/Grade Distribution Rating for Mining Methods Part 1 (Miller-Tait et. al., 1995)

Mining Method	General Shape			Ore Thickness					Ore Plunge		
	Massive	Tabular or platy	Irregular	Very Narrow	Narrow	Intermediate	Thick	Very Thick	Flat	Intermediate	Steep
Open Pit	4	2	3	1	2	3	4	4	3	3	1
Block Caving	4	2	0	-49	-49	0	3	4	3	2	4
Sublevel Stoping	3	4	1	-10	1	3	4	3	2	1	4
Sublevel Caving	3	4	1	-49	-49	0	4	4	1	1	4
Longwall	-49	4	-49	4	3	0	-49	-49	4	0	-49
Room and Pillar	0	4	2	4	3	1	-49	-49	4	0	-49
Shrinkage Stopng	0	4	2	4	4	0	-49	-49	-49	0	4
Cut and Fill	1	4	4	3	4	4	1	0	1	3	4
Top Slicing	1	2	0	1	1	0	2	1	4	2	0
Square Set	0	1	4	4	3	2	0	0	2	3	2

Table No 2. Geometry/Grade Distribution Rating for Mining Methods Part 2 (Miller-Tait et. al., 1995)

Mining Method	Grade Distribution			Depth		
	Uniform	Gradation	Erratic	Shallow	Intermediate	Deep
Open Pit	3	3	2	4	0	-49
Block Caving	3	2	2	2	3	3
Sublevel Stoping	4	4	3	3	4	2
Sublevel Caving	3	2	2	3	2	2
Longwall	4	1	0	2	2	3
Room and Pillar	4	2	0	3	3	2
Shrinkage Stopng	3	2	2	3	3	2
Cut and Fill	2	3	4	2	3	4
Top Slicing	2	1	1	2	1	1
Square Set	0	1	3	1	1	2

Table No 3. Rock Mass Rating for Mining Methods (Miller-Tait et. al., 1995)

Mining Method	Ore Zone					Hanging Wall					Footwall				
	Very Weak	Weak	Moderate	Strong	Very Strong	Very Weak	Weak	Moderate	Strong	Very Strong	Very Weak	Weak	Moderate	Strong	Very Strong
Open Pit	3	3	3	3	3	2	3	4	4	4	2	3	4	4	4
Block Caving	4	3	2	0	-49	3	3	3	2	2	3	3	3	2	2
Sublevel Stoping	1	3	4	4	4	-49	0	3	4	4	0	0	2	3	3
Sublevel Caving	3	4	3	1	0	4	4	3	2	2	1	2	3	3	3
Longwall	6	6	4	2	2	6	5	4	3	3	-	-	-	-	-
Room and Pillar	-49	0	3	5	6	-49	0	3	5	6	-	-	-	-	-
Shrinkage Stopng	0	1	3	3	3	0	0	2	4	4	0	0	2	3	3
Cut and Fill	0	1	2	3	3	3	5	4	3	3	3	3	2	2	2
Top Slicing	3	2	1	1	0	0	0	2	3	3	0	0	1	2	2
Square Set	4	4	1	0	0	4	4	1	0	0	3	1	0	0	0

Table No 4. Rock Substance Strength for Mining Methods (Miller-Tait et. al., 1995)

Mining Method	Ore Zone				Hanging Wall				Footwall			
	Very Weak	Weak	Moderate	Strong	Very Weak	Weak	Moderate	Strong	Very Weak	Weak	Moderate	Strong
Open Pit	4	3	3	3	3	3	4	4	3	3	4	4
Block Caving	4	2	1	0	4	3	2	0	4	3	2	1
Sublevel Stoping	0	2	4	4	0	1	4	5	0	1	3	3
Sublevel Caving	2	3	3	2	4	3	2	1	1	2	2	2
Longwall	6	5	2	1	6	5	2	2	-	-	-	-
Room and Pillar	0	0	3	6	3	0	2	6	-	-	-	-
Shrinkage Stopng	0	1	3	4	0	1	3	4	0	2	3	3
Cut and Fill	0	1	3	3	3	5	4	2	1	3	2	2
Top Slicing	3	2	1	0	3	2	2	2	2	2	1	1
Square Set	4	3	1	0	4	2	1	0	3	2	0	0