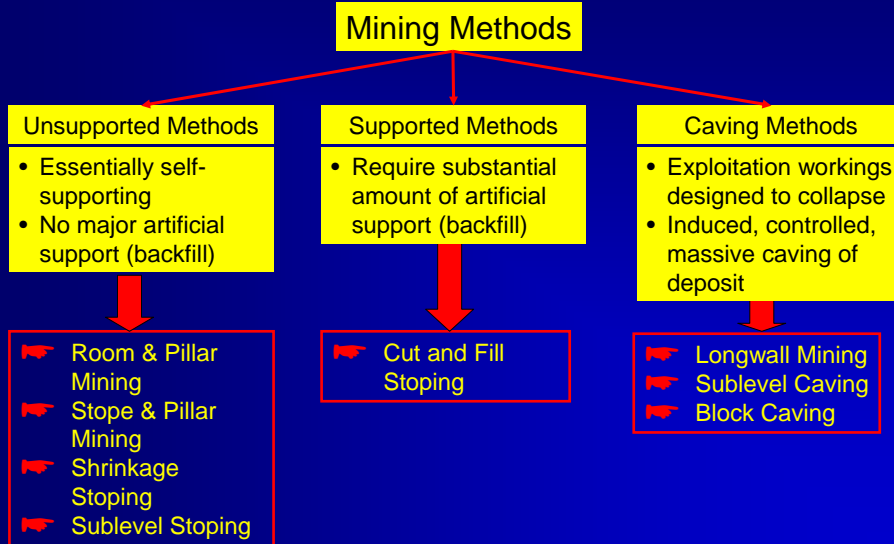


Selection of Mining Methods



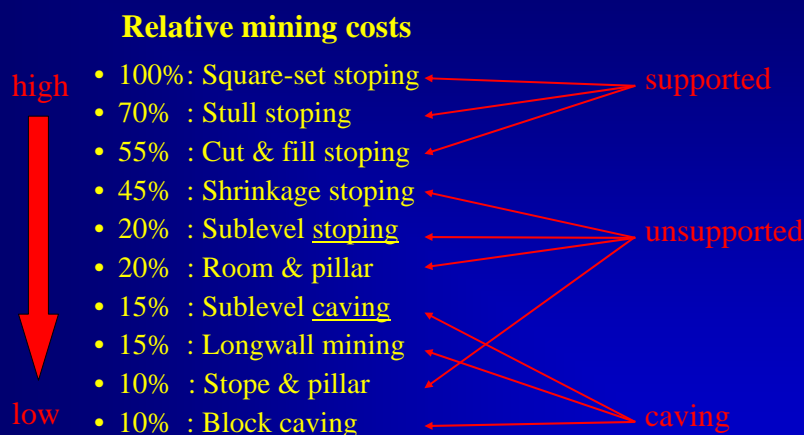
General Observations

- Underground mining is versatile with regard to depth, ore strength and rock strength
- Except for block caving underground mining is not suited for large ore bodies with low grades
- Unsupported mining methods are most widely used
- Supported methods are appropriate for difficult conditions but less productive
- Caving methods are highly productive but restricted because of size requirements and subsidence

Factors in Mining Method Selection

- ☛ **Spatial characteristics of deposit**
 - ⇒ size, shape, attitude, depth
- ☛ **Geologic, hydrologic conditions**
 - ⇒ mineralogy, chemical composition, structure, planes of weakness, uniformity, alteration, weathering, groundwater
- ☛ **Geotechnical properties**
 - ⇒ elastic properties, plastic or viscoelastic behavior, stress, consolidation, compaction, competence, other physical properties
- ☛ **Economic considerations**
 - ⇒ reserves, production rate, mine life, cost comparison
- ☛ **Technological factors**
 - ⇒ mine recovery, dilution, flexibility, selectivity, concentration or dispersion of workings, capital, labor, mechanization intensity
- ☛ **Environmental concerns**
 - ⇒ ground control, subsidence, atmospheric control, work force

Cost of Mining Methods



Relative mining cost includes **capital** expenses, **indirect operating** costs (incl. overheads), **direct** operating costs (**development** and **exploitation**, including **maintenance**); expressed per ton (or m³) of mineral production

Techniques for Selection

- Various techniques were developed for mining method selection
- Most famous are the techniques by Morrison, Laubscher, Nicholas, Boshkov/Wright and Hartmann
- Hartmann's method is qualitative and should be used for a first approach
- Hartmann's method is described as an example in the following slides

Conditions: Unsupported Methods

	Room and Pillar Mining	Stope and Pillar Mining	Shrinkage Stopping	Sublevel Stopping
Ore strength	Weak to moderate	Moderate to strong	Strong (should not pack)	Moderate to strong
Rock strength	Moderate to strong	Moderate to strong	Strong to fairly strong	Fairly strong to strong
Deposit shape	Tabular	Tabular, lenticular	Tabular, lenticular	Tabular, lenticular
Deposit dip	Low, preferably flat	Low to moderate	Fairly steep	Fairly steep
Deposit size	Large, thin	Any, preferably large, moderately thick	Thin to moderate	Fairly thick to moderate
Ore grade	Moderate	Low to moderate	Fairly high	Moderate
Ore uniformity	Fairly uniform	Variable	Uniform	Fairly uniform
Depth	Shallow to moderate	Shallow to moderate	Shallow to moderate	Moderate

Conditions: Supported Methods

	Cut and fill
Ore strength	Moderate to strong
Rock strength	Weak to fairly weak
Deposit shape	Tabular to irregular
Deposit dip	Moderate to fairly steep
Deposit size	Thin to moderate
Ore grade	Fairly high
Ore uniformity	Moderate, variable
Depth	Moderate to deep

Conditions: Caving Methods

	Longwall Mining	Sublevel Caving	Block Caving
Ore strength	Any (should crush, not yield)	Moderate to fairly strong	Weak to moderate, cavable
Rock strength	Weak to moderate, cavable	Weak to fairly strong, cavable	Weak to moderate, cavable
Deposit shape	Tabular	Tabular or massive	Massive or thick tabular
Deposit dip	Low, preferably flat	Fairly steep	Fairly steep
Deposit size	Thin, large areal extent	Large, thick	Very large, thick
Ore grade	Moderate	Moderate	Low
Ore uniformity	Uniform	Moderate	Fairly uniform
Depth	Moderate to deep	Moderate	Moderate

Classification of Ore and Rock Strength

Mineral or Rock	Relative Strength	Compressive Strength [MPa]
Coal, decomposed and badly altered rock	Very weak	<40
Friable sandstone, mudstone, weathered rock, soft shale	Weak	40-100
Shale, limestone, sandstone, schistose rock	Moderate	100-140
Most igneous rock, strong metamorphic rock, hard limestone and dolomite	Strong	140-200
Quartzite, basalt, diabase	Very strong	>220

Selection (Non-coal Deposits)

Method	Ore strength			Rock strength			Deposit		Geometry		Dip/Inclination			
	Weak	Moderate	Strong	Weak	Moderate	Strong	Thin	Thick	Narrow	Wide	Masses	Flat	Moderate	Steep
Stope and pillar	X	X		X	X	X	X	X				X	X	
Shrinkage stoping	X	X		X	X				X	X			X	X
Sublevel stoping	X	X		X	X				X	X	X			X
Cut and fill stoping	X	X	X	X					X	X	X		X	X
Stull stoping		X	X		X				X				X	X
Square set stoping	X			X	X				X	X	X		X	X
Sublevel caving		X	X	X	X					X	X			X
Block caving	X	X		X	X					X	X			X

Selection (Any Deposit) 1

Deposit Shape	Deposit Orientation	Deposit Thickness	Ore Strength	Rock Strength	Applicable Method(s)
Tabular	Horizontal, flat	Thin	Strong	Strong	Room and pillar, stope and pillar mining
			Weak, strong	Weak	Longwall mining
		Thick	Strong	Strong	Stope and pillar mining
			Weak, strong	Weak	Sublevel caving
Tabular	Vertical, steep	Thin	Strong	Strong	Shrinkage stoping, Sublevel stoping
			Strong	Weak	Cut and fill stoping, square set stoping, stull stoping
			Weak	Strong	Square set stoping
			Weak	Weak	Square set stoping

Selection (Any Deposit) 2

Deposit Shape	Deposit Orientation	Deposit Thickness	Ore Strength	Rock Strength	Applicable Method(s)
Tabular	Vertical, steep	Thick	Strong	Strong	Shrinkage stoping, Sublevel stoping
			Strong	Weak	Cut and fill stoping, sublevel caving, square set stoping
			Weak	Strong	Sublevel caving, block caving, square set stoping
			Weak	Weak	Sublevel caving, block caving, square set stoping
Massive	-	-	Strong	Strong	Shrinkage stoping, Sublevel stoping
			Weak	Weak, strong	Sublevel caving, block caving, square set stoping

Conclusion

- **There is almost always a technically feasible method for underground mining!**
- Underground mining methods compete with each other within economic limits