CLASSIFICATION OF MINING SYSTEMS

Types of Mining Methods

Methods and procedures

WHY DO WE MINE MINERALS?

Mineral products are essential components for many elements and properties we used in our daily life- cell phones, cars, energy towers, solar panels, wind turbines, fertilizers, machinery and all kinds of construction and so on. To meet the demand, we have to exploit and explore mineral resources and extracted continuously

WHAT IS MINING?

Mining is the process to extract the ore or mineral resources from ground. An ore is a natural material with high concentration of economically valuable minerals that can be mined for a profit.

STAGES IN THE LIFE OF A MINE

Stages	Procedure	Time-span
Precursors to Mining		
1. Prospecting	Search for ore a. Prospecting methods Direct: Physical, geological Indirect: Geophysical, geochemical b. Locate favorable loci (maps, literature, old mines) c. Air: Aerial photography, airborne geophysics, satellite d. Surface: Ground geophysics, geology e. Spot anomaly, analyze, evaluation	1-3 years
2. Exploration	Defining extent and value of ore (examination/evaluation) a. Sample (drilling or excavation) b. Estimate tonnage and grade c. Valuate deposit: Present value = Income – Cost Feasibility study: make decision to abandon or develop	2-5 years

Stages	Procedure	Time-span
Mining Proper		
3. Development	Opening up ore deposit for production a. Acquire mining rights (purchase or lease), if not done in stage 2 b. File environmental impact statement, technology assessment, permit c. Construct access roads, transport system d. Locate surface plant, construct facilities e. Excavate deposit (strip or sink shaft)	2-5 years
4. Exploration	Large-scale production of ore a. Factors to be considered: Geologic, geographic, economic, environmental, societal safety b. Types of mining methods Surface: Open pit, opencast etc. Underground: Room and pillar, Cut & fill, Longwall, block caving c. Monitor costs and economic payback	10-30 years
Post-Mining		
5. Reclamation	Restoration of site a. Removal of plant and buildings b. Reclamation of waste and tailings dumps c. Monitoring of discharges	1-10 years

SURFACE MINING METHODS

Some common surface mining methods are:

Open-pit : Reclamation after completion

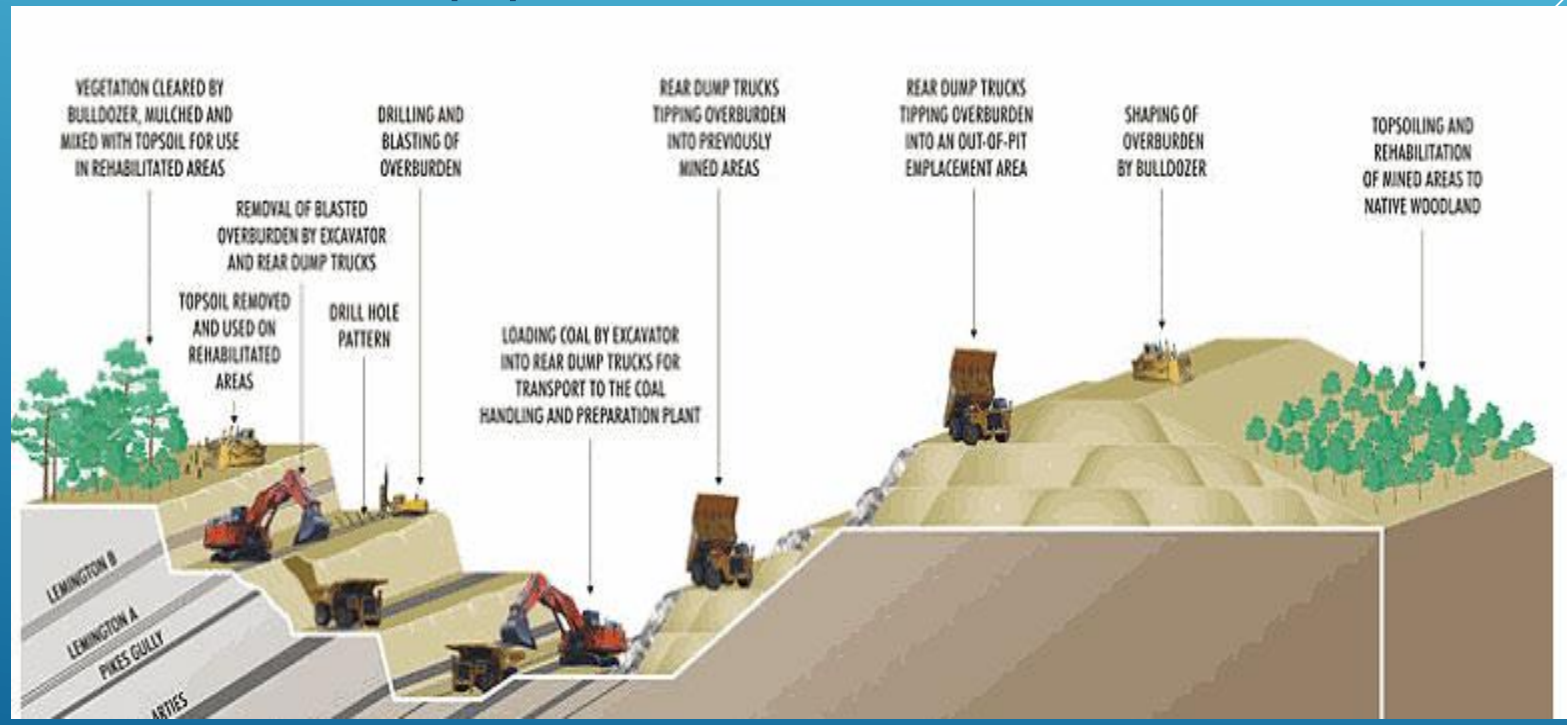
Open-cast : Reclamation during mining

Quarries : Stone, crushed rock, sand, gravel

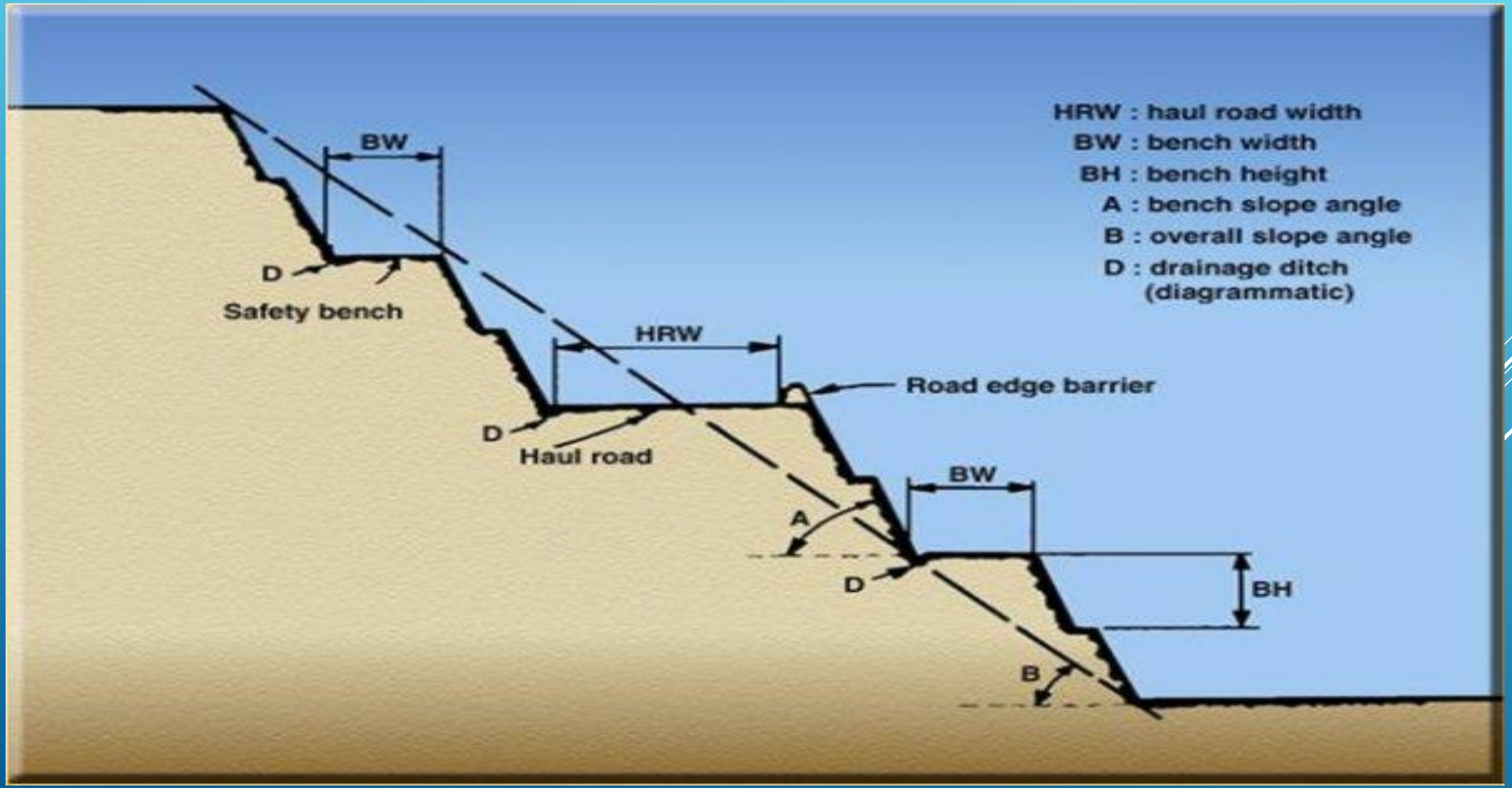
Strip Mining : Removing surface (Overburden rock) in strips up to the resources

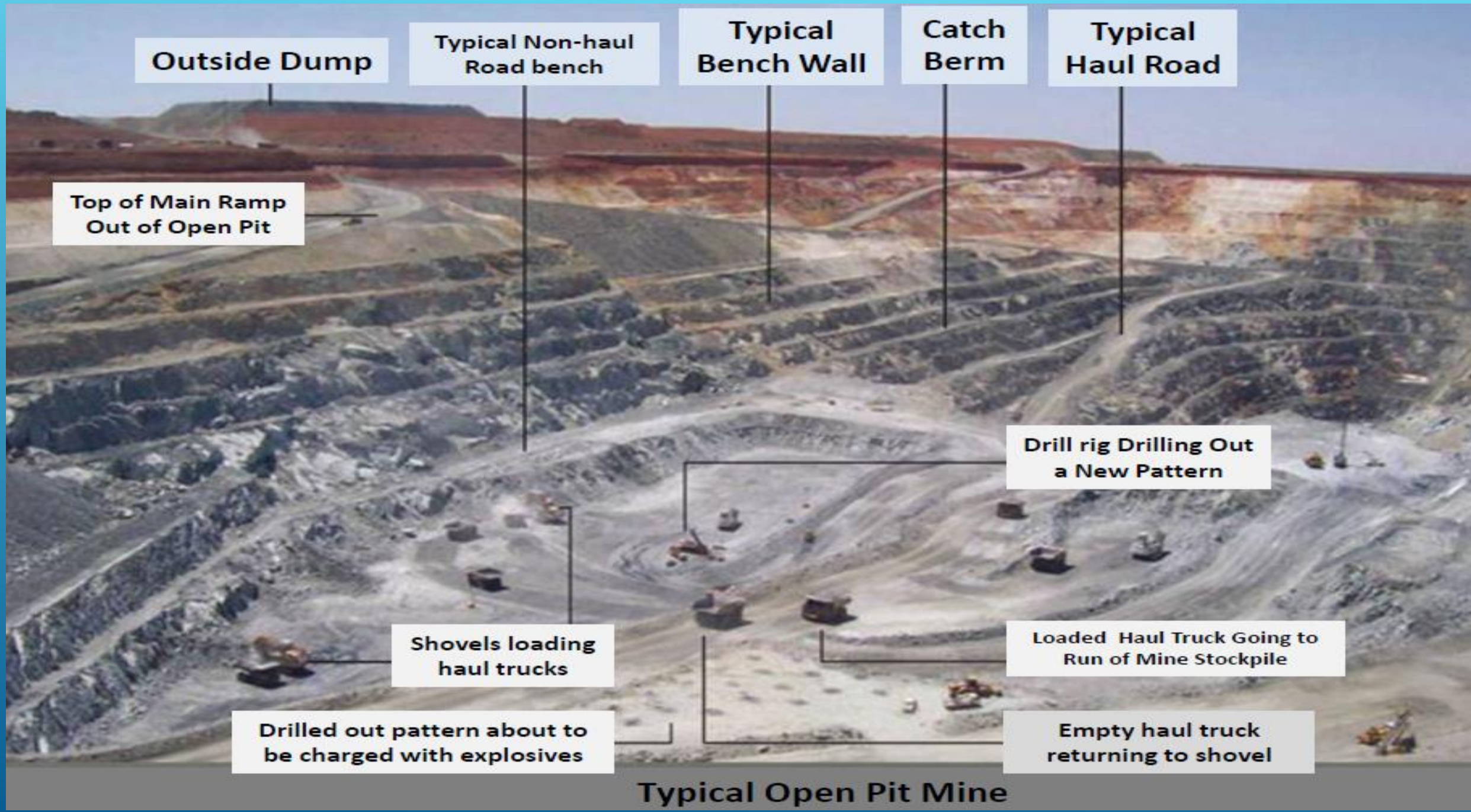
SURFACE MINING

A mine in which ore lies near surface and can be extracted by removing the covering layers of rock or soil. Almost all surface mining operations are exposed to the elements and require no roof support



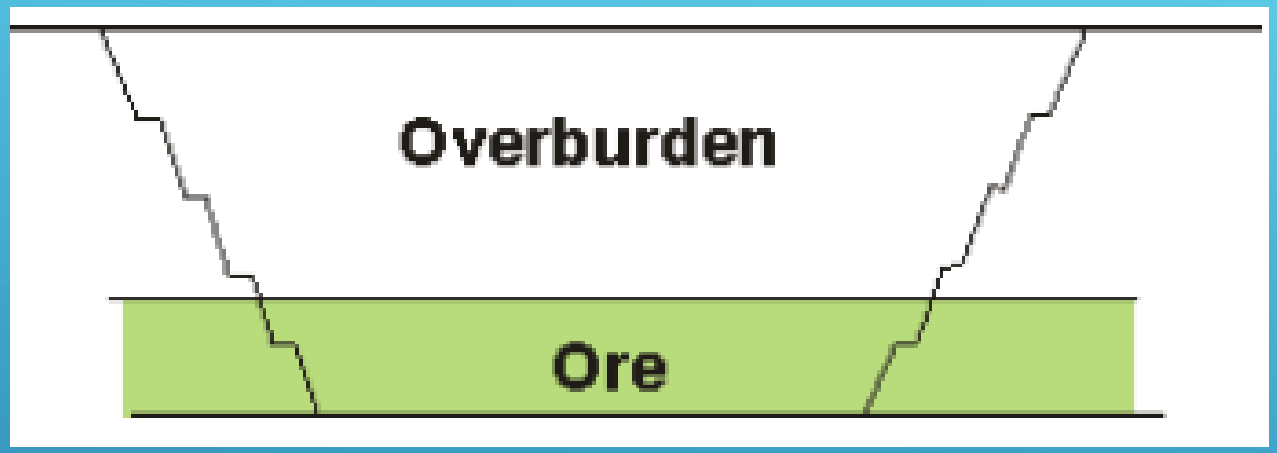
SURFACE MINING TERMINOLOGY



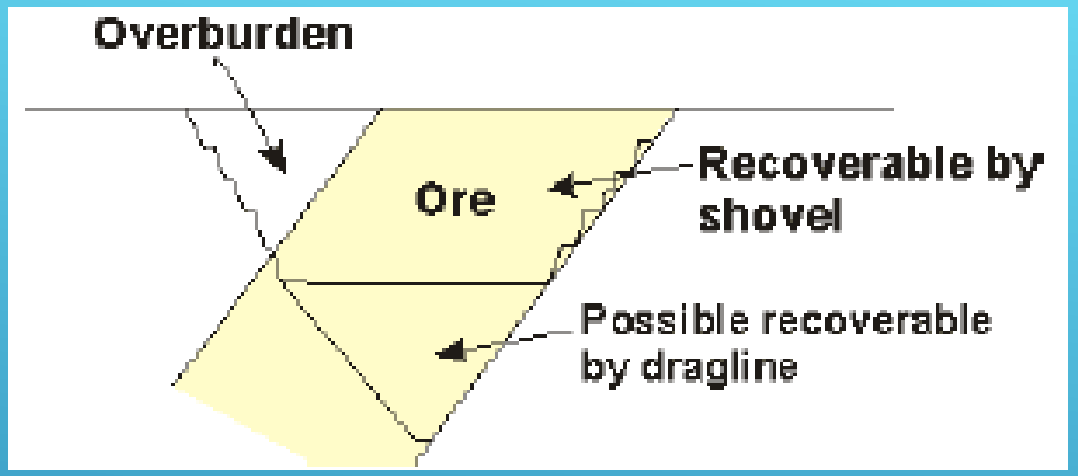


Typical Open Pit Mine

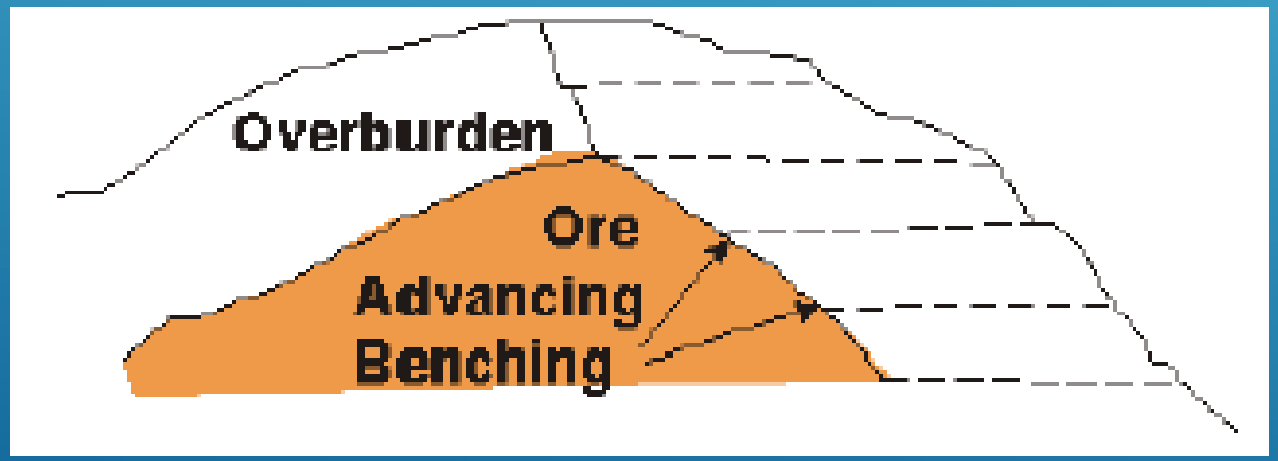
Various open-pit and orebody configuration:



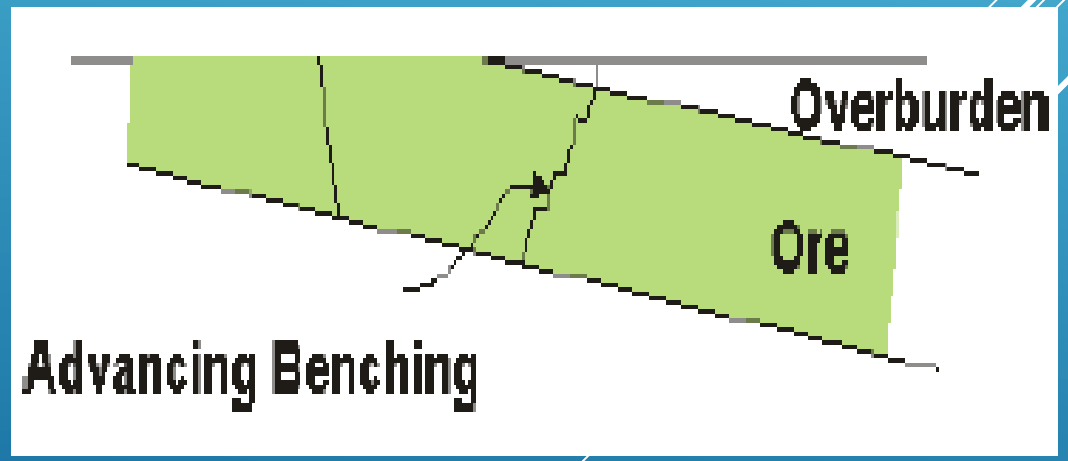
Flat lying seam or bed, flat terrian



Dipping seam or bed, flat terrian



Thick bedded deposit, little orverburden, flat terrian



Massive deposit, high relief

SUB-SURFACE/UNDERGROUND MINING

Mineral exploitation in which all the extraction is carried out beneath the surface of earth developing openings and passage up to the mineral resources.

UNDERGROUND MINING TERMINOLOGY

Adit: Horizontal or nearly horizontal entrance to a mine.

Back: Roof or overhead surface of an underground excavation.

Chute: Loading arrangement that utilizes gravity to move material from a higher level to a lower level.

Cone: Funnel-shaped excavation located at the top of a raise used to collect rock from the area above.

Crosscut: Horizontal or nearly horizontal underground opening driven to intersect an ore body.

Dip: Angle at which an ore deposit is inclined from the horizontal.

Drawpoint: Place where ore can be loaded and removed. A drawpoint is located beneath the stoping area, and gravity flow transfers the ore to the loading place.

Drift: Horizontal or nearly horizontal underground opening.

Finger Raise: Typically, a system of several raises that branch together to the same delivery point. Used for transferring ore.

Footwall: Wall or rock under the ore deposit.

Grizzly: Arrangement that prevents oversized rock from entering an ore transfer system. A grizzly usually consists of a steel grating for coarse screening or scalping.

Hanging Wall: Wall or rock above an ore deposit.

Level: System of horizontal underground workings connected to the shaft. A level forms the basis for excavation of the ore above or below.

Manway: Underground opening that is intended for personnel access and communication.

Ore: Mineral deposit that can be worked at a profit under existing economic conditions.

Ore Pass: Vertical or inclined underground opening through which ore is transferred.

Prospect: Mineral deposit for which the economic value has not yet been proven.

Raise: Underground opening driven upward from one level to a higher level or to the surface; a raise may be either vertical or inclined (*compare winze*).

Ramp: Inclined underground opening that connects levels or production areas; ramps are inclined to allow the passage of motorized vehicles. Ramps usually are driven downward.

Shaft: Vertical or inclined underground opening through which a mine is worked.

Slot: Vertical or inclined ore section excavated to open up for further stoping.

Stope: Underground excavation made by removing ore from surrounding rock.

Strike: Main horizontal course or direction of a mineral deposit.

Sublevel: System of horizontal underground workings; normally, sublevels are used only within stoping areas where they are required for ore production.

Wall Rock: Wall in which an ore deposit is enclosed.

Waste: Barren rock or rock of too low a grade to be mined economically.

Winze: Vertical or inclined underground opening driven downward from one level to another level or from the surface to a level (*compare raise*).

DIFFERENT TYPE OF UNDERGROUND MINING METHODS

Supported methods	Unsupported methods	Caving methods
1) Cut and fill stoping	1) Room-and-pillar mining	1) Longwall mining
2) Stull stoping	2) Stope-and-pillar mining	2) Sublevel caving
3) Square set stoping	3) Shrinkage stoping	3) Block Caving
	4) Sublevel stoping	

TABLE: METHODS FOR UNDERGROUND MINE

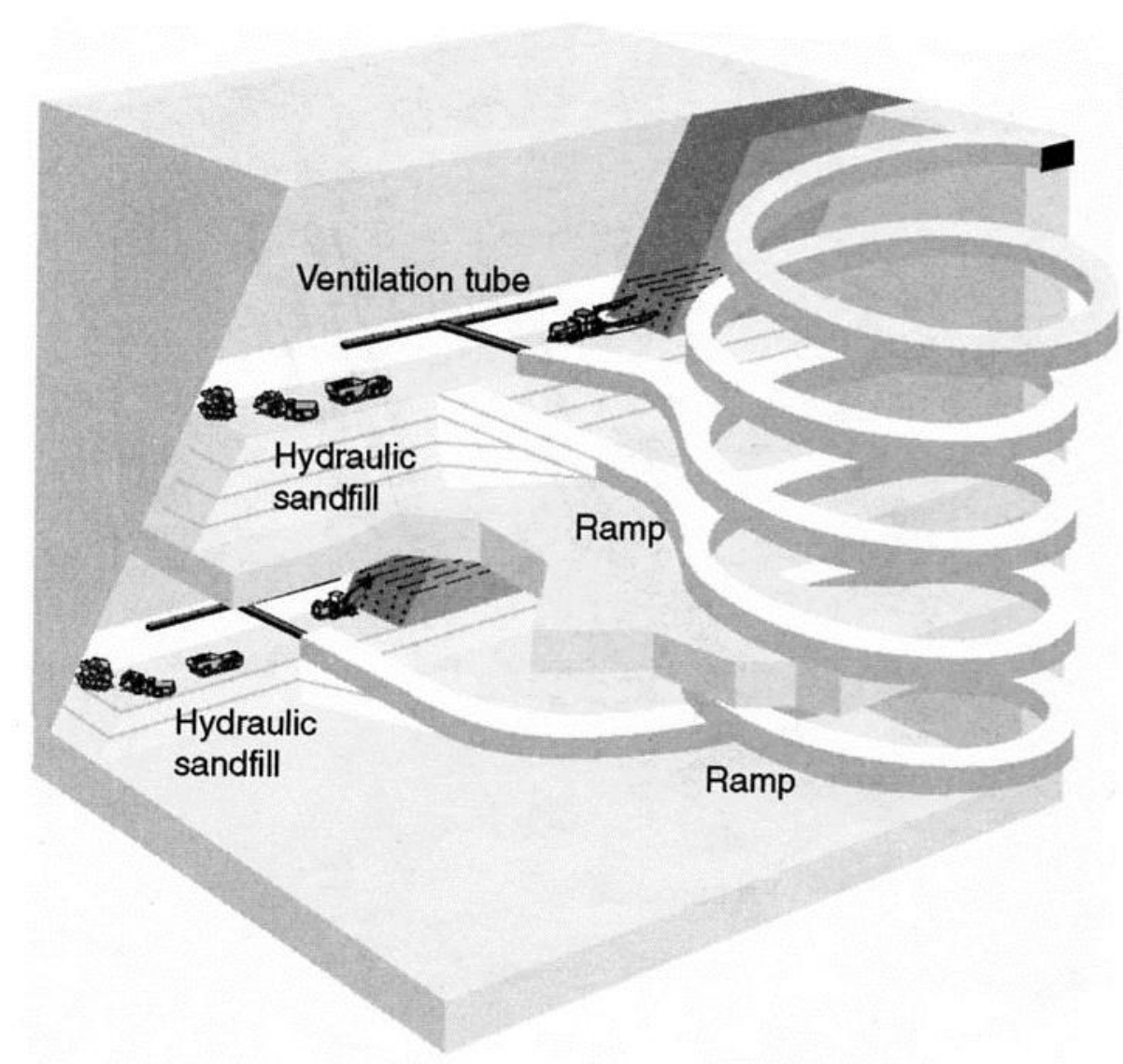
Underground methods	Unsupported				Supported		Caving		
Factor	*Room and Pillar*	*Stope and Pillar*	*Shrinkage Stoping*	*Sublevel Stoping*	*Cut and Fill Stoping*	*Square Set Stoping*	*Longwall Stoping*	*Sublevel Caving*	*Block Caving*
Ore strength	Weak / Moderate	Moderate/ Strong	Strong	Moderate/ Strong	Moderate/ Strong	Weak	Any	Moderate/ Strong	Weak/ Moderate
Rock strength	Moderate / Strong	Moderate/ Strong	Strong	Fairly Strong	Weak	Weak	Weak / Moderate	Weak	Weak / Moderate
Deposit shape	Tabular	Tabular / Lenticular	Tabular / Lenticular	Tabular / Lenticular	Tabular / Irregular	Any	Tabular	Tabular / Massive	Massive / Thick
Deposit dip	Low / Flat	Low / Moderate	Fairly Steep	Fairly Steep	Fairly Steep	Any	Low / Flat	Fairly Steep	Fairly Steep
Deposit size	Large / Thin	Any	Thin / Moderate.	Thick / Moderate	Thin / Moderate	Usually Small	Thin / Wide	Large Thick	Very Thick
Ore grade	Moderate	Low / Moderate	Fairly High	Moderate	Fairly high	High	Moderate	Moderate	Low
Ore uniformity	Uniform	Variable	Uniform	Uniform	Variable	Variable	Uniform	Moderate	Uniform
Depth	Shallow / Moderate	Shallow / Moderate	Shallow / Moderate	Moderate	Moderate / Deep	Deep	Moderate / Deep	Moderate	Moderate

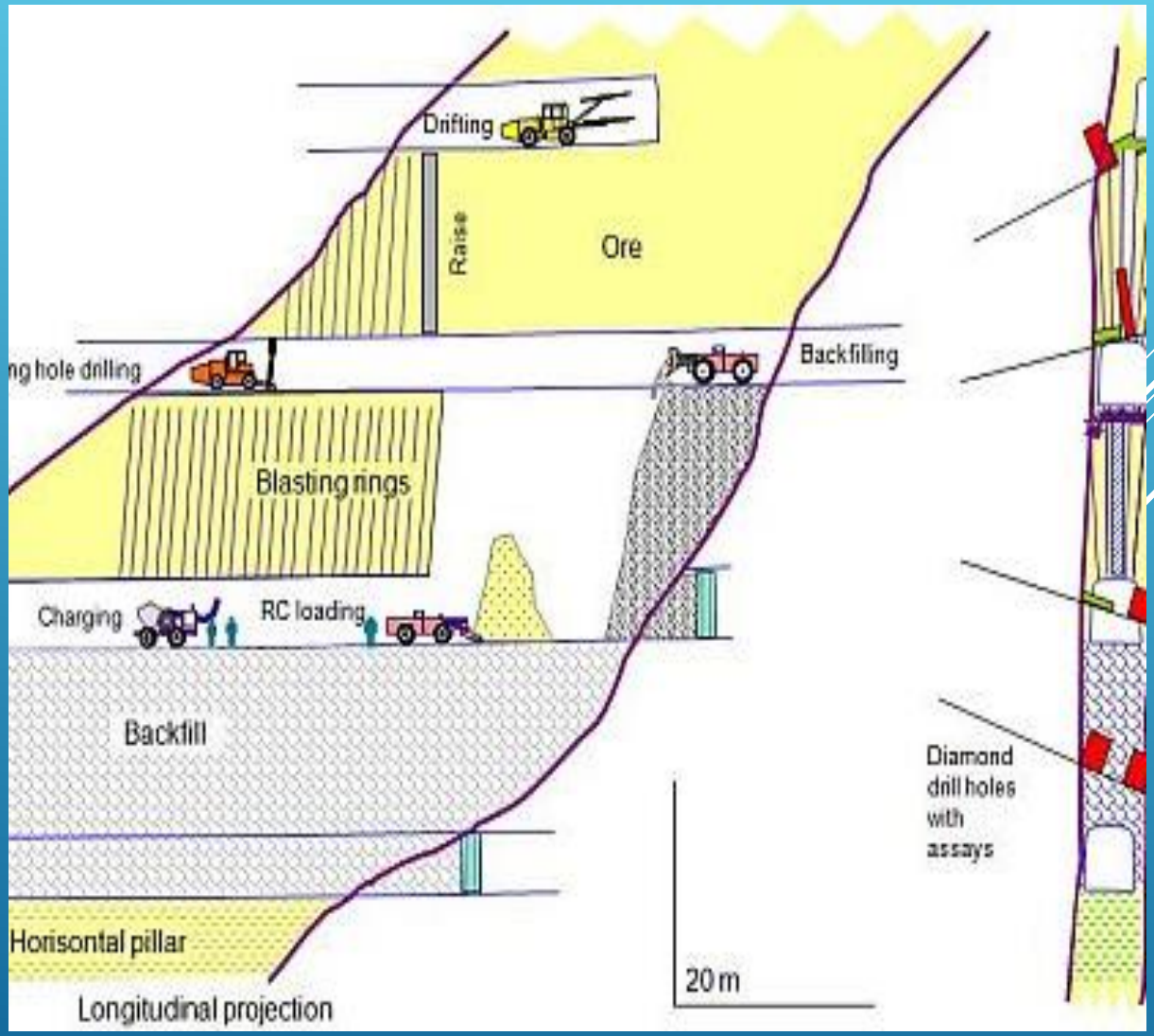
METHODS AND PROCEDURE

Cut and Fill Stoping: This method is used in vertical stopes and in mining high-grade irregular ore bodies.

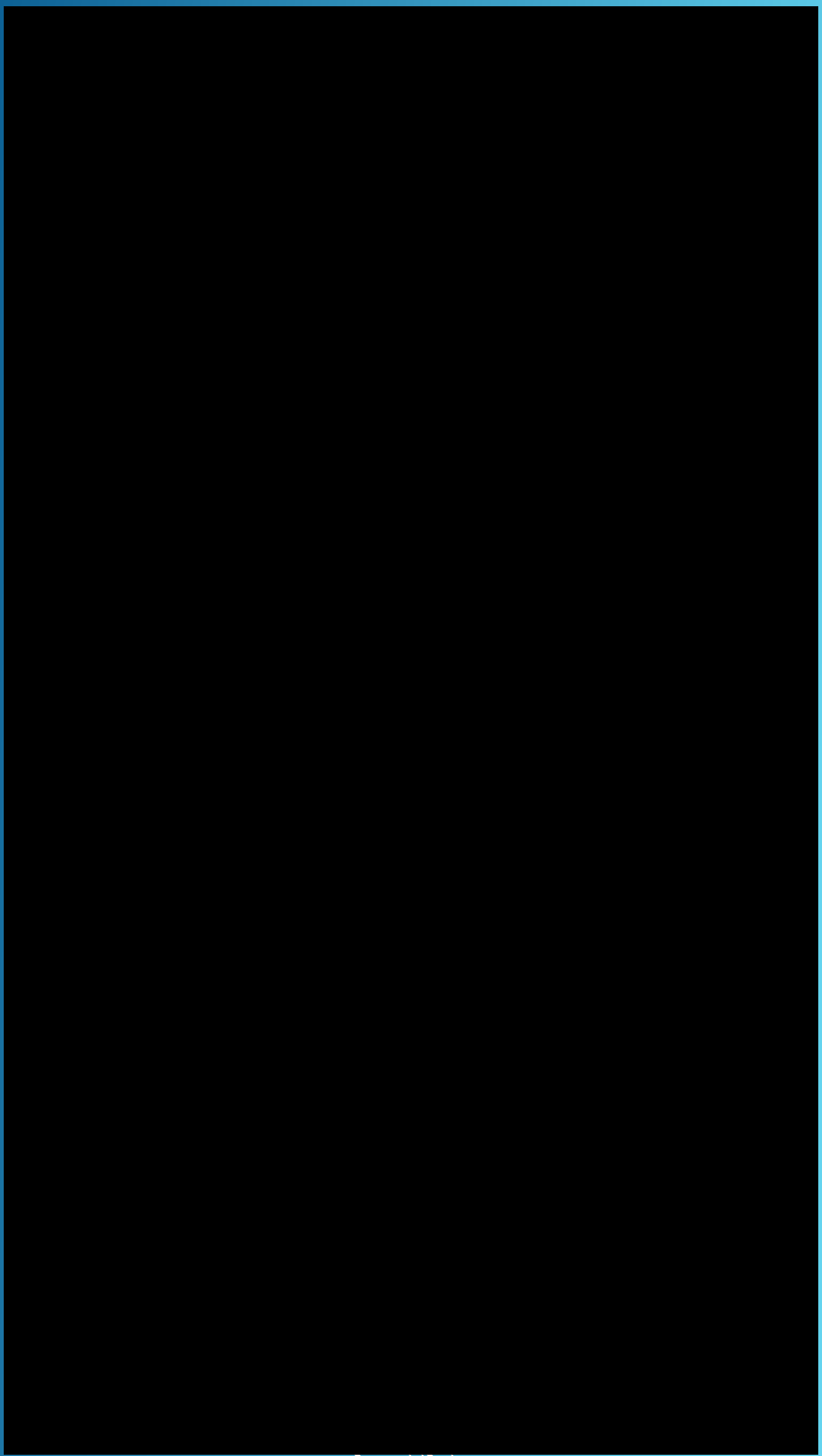
- The rock mass surrounding the ore deposit is usually week
- Unable to support loads over and extended stoping height
- Successive cutting of the ore into horizontal slices is carried out starting from the bottom and progressing upwards towards the surface
- The ore is extracted in horizontal slices and replaced with backfill material
- The fill material varies, depending on the support required, and the material available

CUT AND FILL STOPING: (CONT.)





CUT AND FILL STOPING: (CONT.)



CUT AND FILL STOPING: (CONT.)

- It is one of the popular and expensive but selective mining method, with low ore loss and dilution
- Is done only in high grade minerals/resources (why)
- Ore is drilled, blasted and removed from stope
- The ore is mined in slices
- Voids are backfilled with a variety of fill type to support the walls ----rock waste, tailings, sand or other suitable materials

MINING PROCEDURE OF CUT AND FILL STOPING

- In cut and fill stoping, the orebody is retrieved in horizontal slices beginning at the very bottom and advancing upwards towards the surface.
- Ramps (inclined tunnels) are excavated to connect the surface to the underground ore body.
- Drifts are excavated to come in contact with the ore slices. The slices are drilled using a jumbo, blasted by charging the drill holes with explosives, and ore is removed by using dump trucks or Load Haul Dump (LHD) vehicles.
- The ore is dumped into an ore pass, an inclined tunnel where ore is transported to a lower elevation in the mine.

- The ore is picked up at the other end of the ore pass by a LHD to be transported out of the mine through a ramp (inclined tunnel).
- Once a slice is completely mined out, the empty space is partially backfilled hydraulically.
- The backfill material used can be a mixture of sand and rocks, waste rock with cement, or dewatered mill tailings (rejected low grade ore from processing, usually fine and sandy).
- The backfill underground serves to keep the mine walls stable and also as the floor for mining the next slice.
- Mining continues upwards towards the surface until the orebody is depleted.

BASIC DIFFERENTIATION OF MINING METHODS

Issues	Underground Mining	Open-pit Mining
Deposits	Relatively small, high grade or deep with sub-vertical ore zone	Relatively large, low grade or shallow, with sub-horizontal ore zone
Geology	Structurally controlled veins and breccias	Lithology controlled stockworks, disseminated zones
Resources/ Reserves	Generally difficult or not cost effective to prove up large resources/reserves	Generally cost effective to establish 10 to 15 year resource/reserve life
Productivity	500 to 8,000 tonnes per day	5,000 to 100,000 tonnes per day
Environmental	Generally easier to permit, limited footprint. Relatively cheap to reclaim	Large footprint from pit, waste dumps and tailings, relatively expensive to reclaim
Mine Life	To > 100 years	10 to 25 years, rarely longer