Introduction to Mining

MEC 13103

INTRODUCTION TO MINING (S) (MEC 13103)

Syllabus:

- Mining – definition and economic importance; Mine – definition, different types and classification;
- Mine life cycle;
- Mineral deposit – different types and their classification;
- Mineral resources of India;
- Modes of entry to a mine – shaft, incline, decline, adit and box-cut.
- Overview of surface mining: Types of surface mines, unit operations, basic bench geometry, applicability & limitations and advantages & disadvantages.
- Overview of underground mining:
  - Different coal mining methods and their applicability & limitations;
  - Different metal mining methods and their applicability & limitations;
- Basic concepts of transportation, ventilation, illumination and support in underground mines.

Mining and Mining Engineering

- **Mining** consists of the processes, the occupation, and the industry concerned with the extraction of minerals from the earth.

- **Mining engineering**, on the other hand, is the art and the science applied to the processes of mining and to the operation of mines.

- **Access** for extracting minerals from the earth is to drive (construct) an excavation or an opening to serve as a means of entry from the existing surface to the mineral deposit. Whether the openings lie near the surface or are placed underground this fixes the locale of the mine.

- **The mining method** specific details of the procedure, layout, equipment, and system used for mining. This is unique as determined by the physical, geologic, environmental, economic, and legal circumstances that prevail at the site.

The trained professional who relates mining and mining engineering is the **mining engineer**;

He/she is responsible

- for helping to locate and prove minerals in the mines,
- for designing and developing mines, and
- for exploiting and managing mines successfully
- for mine closure to make to sustainable

What is a Mineral Deposit?

Mineral is a solid naturally-occurring compound having a definite chemical composition

Examples:

quartz - SiO_2 (an oxide)

hematite - Fe_2O_3 (another oxide)

covelite - CuS (a sulphide)

Why do we mine minerals?

Economically Important Metal: Concentrations in Earth's Crust

Metal	Concentration (% by weight)
Aluminum	8.0
Iron	5.8
Copper	0.0058
Nickel	0.0072
Zinc	0.0082
Uranium	0.00016
Lead	0.001
Silver	0.000008
Gold	0.0000002

Note for comparison:

Silicon 28%

Oxygen 46%

What is ore grade?

Ore grade is the concentration of economic mineral or metal in an ore deposit and is expressed in:

- Weight percentage (base metals)
- Grams/tonne or oz/ton (precious metals)

Economically Important Metals: Typical Grades of Ore Deposits which is economically extractable:

Metal	Typical Grade (% by weight)
Aluminum	30
Iron	53
Copper	0.5-4
Nickel	1
Zinc	4
Uranium	0.3
Lead	5
Silver	0.01
Gold	0.0001-0.001

Hydrothermal Ore Deposits

As magma cools, more abundant metals (silicon, aluminum) deposit first

Solidification of magma releases water - a *hydrothermal solution*

Minerals precipitate from hydrothermal solution and deposit in cracks or veins in rock

Metamorphic Ore Deposits

Concentration of minerals caused by high temperatures and pressures near intrusions

Examples:

- Lead-zinc deposits
- Diamonds
- Garnets

Sedimentary Ore Deposits

- Accumulation, burial and petrification of vegetation, e.g. Coal, Lime stone Deposits etc.
- Deposition of dense, resistant minerals in streams, lakes etc (Alluvial Deposits), e.g. Placer gold
- Precipitation of minerals from ancient oceans (Evaporite Deposits), e.g. Potash and salt deposits

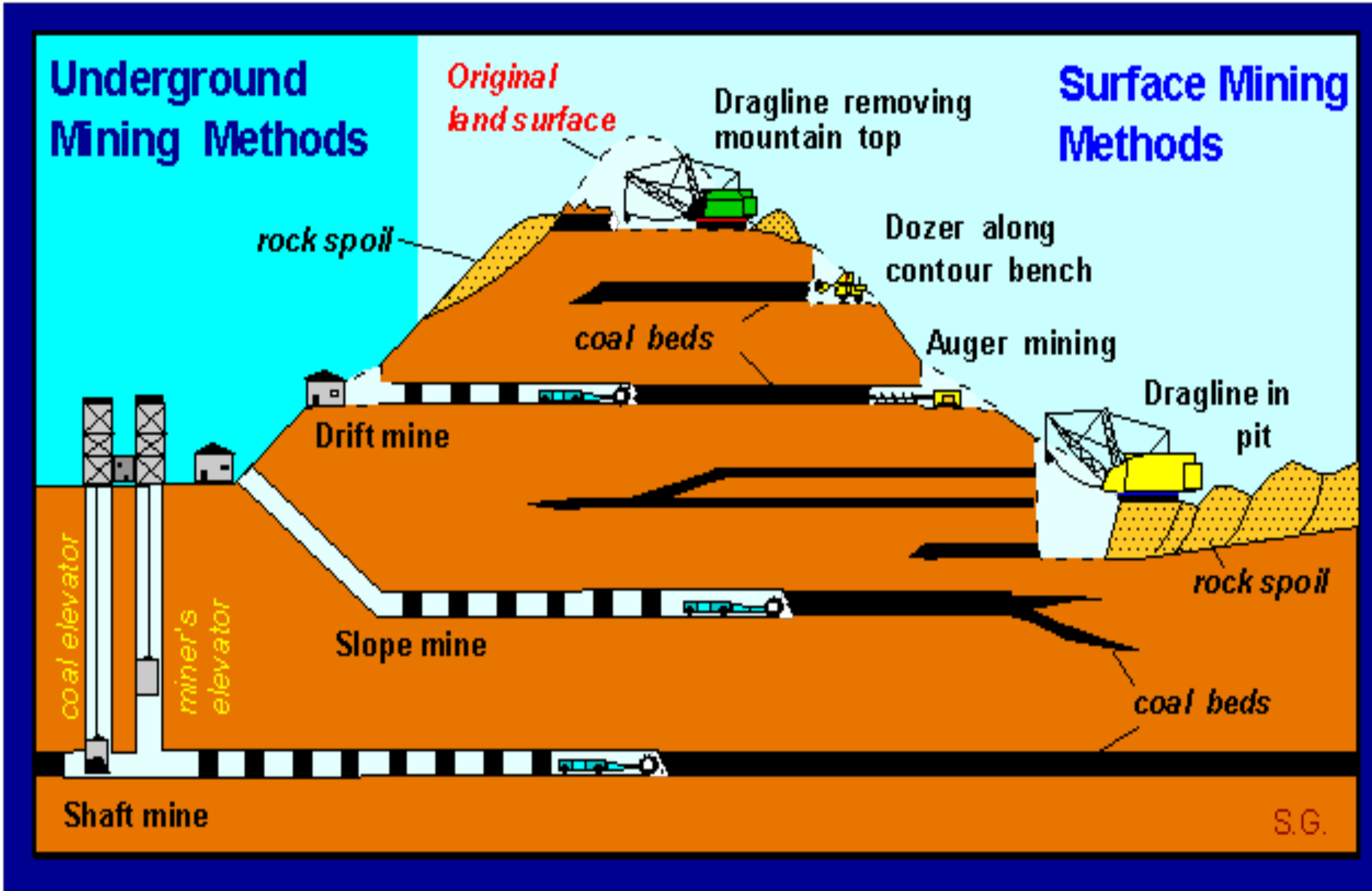
Mining Terminology:

Shaft is a vertical opening/access to a mine driven from the surface to the ore body which is used for transport of ore/manpower & ventilation

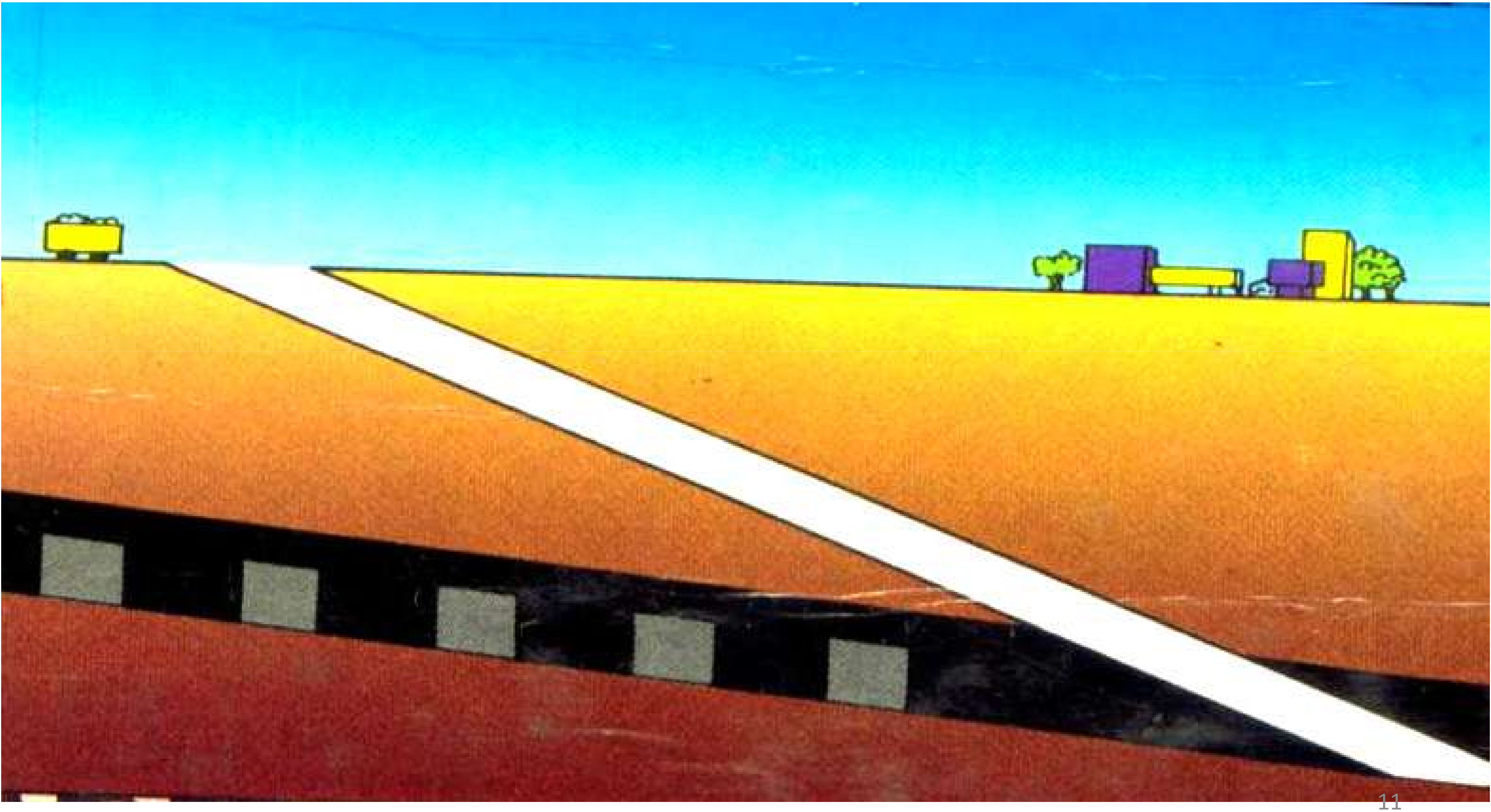
Adit is a horizontal or a nearly horizontal entrance to an underground mine

Slope/Incline: Primary inclined opening, usually a inclined shaft, connecting surface with underground workings

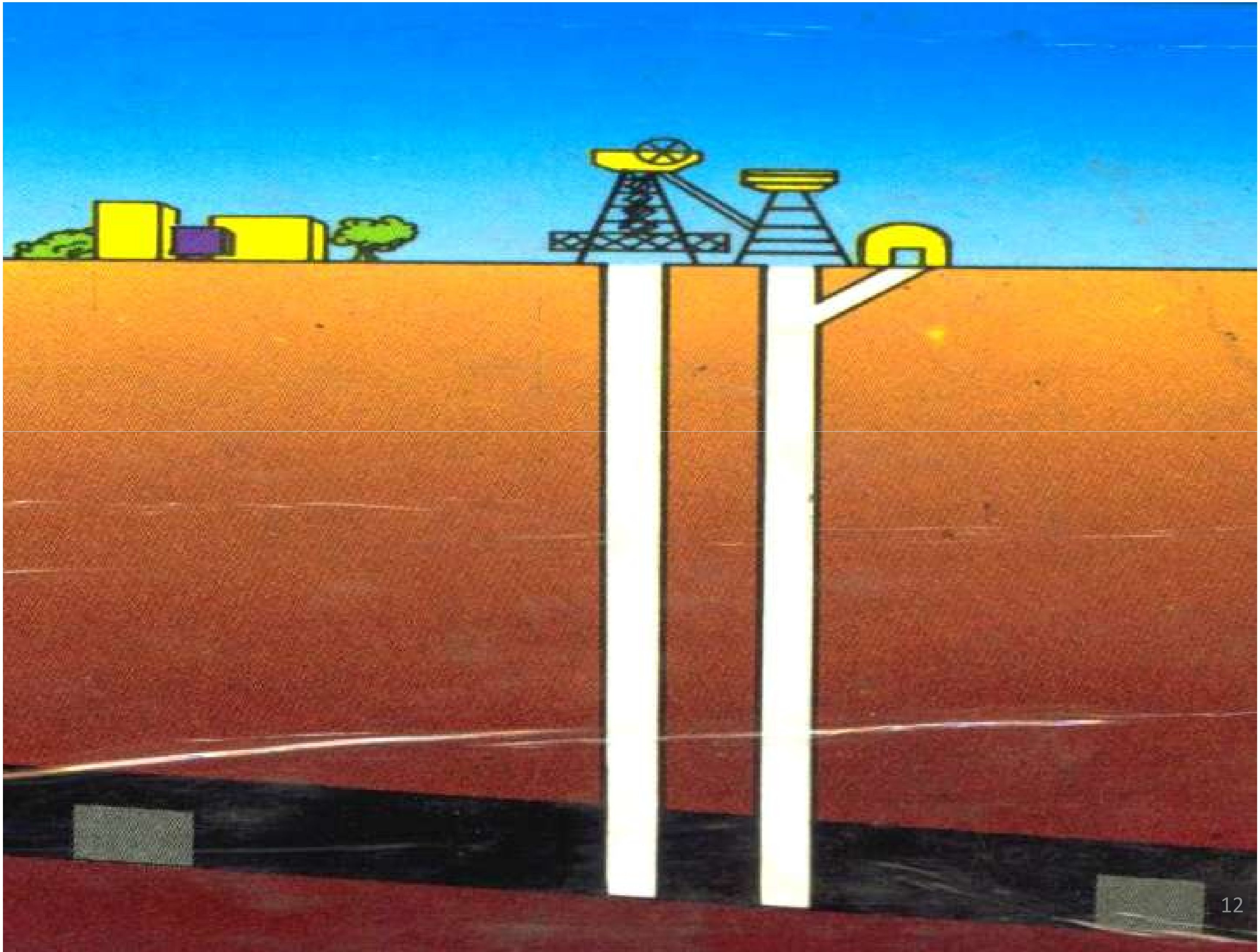
MINING TERMINOLOGY



Incline entry into a seam.



Entry through a shaft



Entry through a shaft

Decline: Secondary inclined opening or may be spiral, driven downward to connect levels on the dip of a deposit.

Drifts/Cross Cuts are Horizontal or nearly horizontal underground drivages to intersect orebody. It is primary or secondary horizontal or near horizontal opening oriented parallel to the strike of the deposit.

Dip Angle at which the orebody is inclined with horizontal

Strike Main horizontal course or direction of a mineral deposit

Footwall Wall or rock below the orebody

Hangwall Wall or rock above the orebody

Vein or lode: It is a natural crack in the earth's crust filled with minerals. Sometimes, mineralized zone is more or less regularly developed in length, width and depth to give it a shape of tabular deposit.

Waste: The material associated with an ore deposit that might be required to be mined to get the ore and must be necessarily discarded. Gangue is a particular type of waste.

Country Rock : waste material adjacent to mineral deposit

Gangue: the valueless mineral particles within an ore deposit that must be discarded

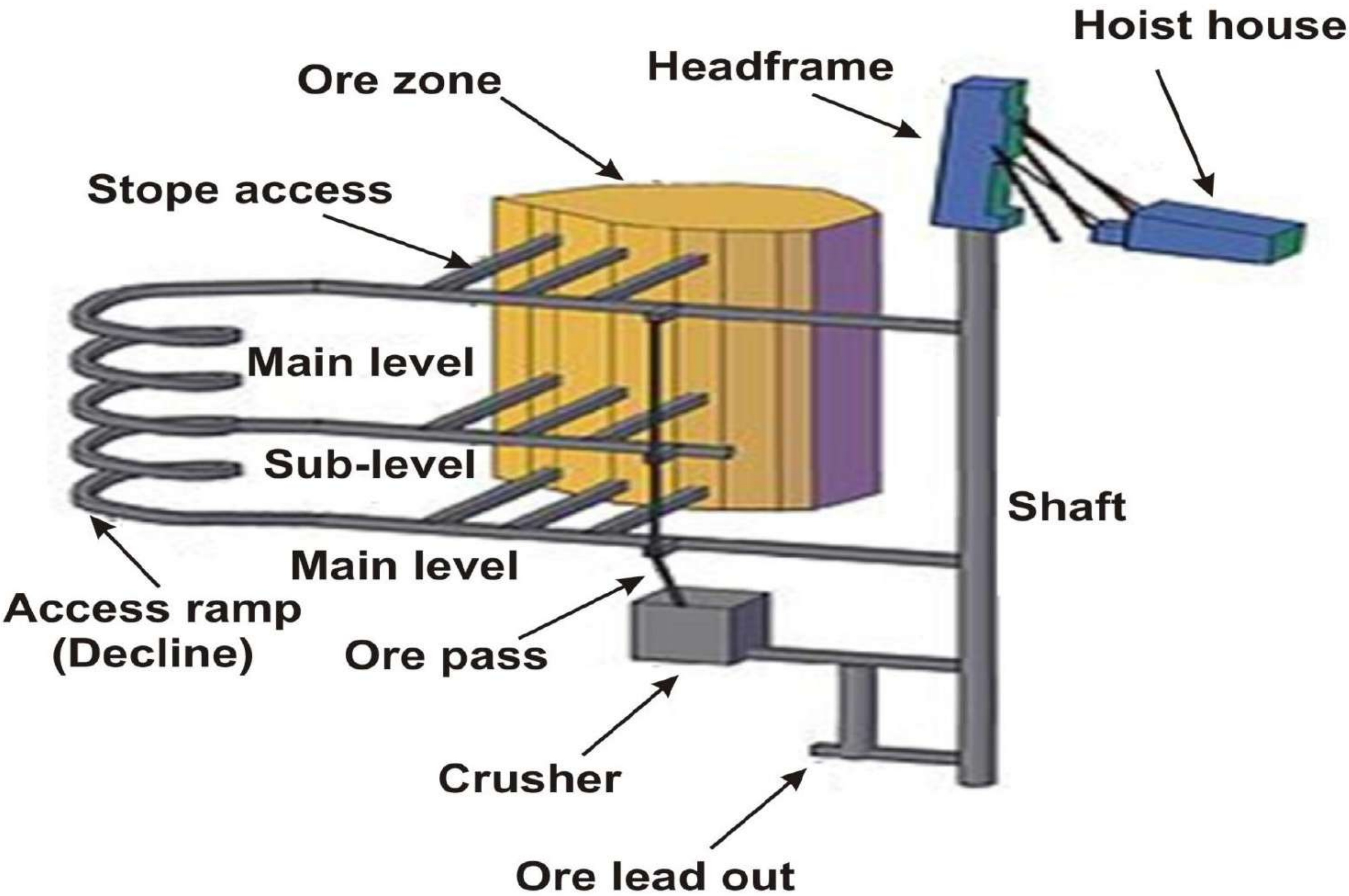
Raise: Secondary or tertiary vertical or near vertical opening driven upward from one level to another

Winze: Secondary or tertiary vertical or near vertical opening driven downward from one level to another

Cross Cuts are Horizontal or nearly horizontal underground drivages to intersect orebody

Stope: This is an opening from which ore is mined which may be vertical or inclined. The stopes are at times backfilled with cemented waste materials

Stoping is the process of extracting the desired ore or other mineral from an underground mine, leaving behind an open space known as a stope.


Hoist house
Headframe
Ore zone
Stope access
Main level
Sub-level
Shaft
Main level
Access ramp
(Decline)
Ore pass
Crusher
Ore lead out

Mine Life Cycle:

Using scientific principles, technological knowledge, and managerial skills, the mining engineer brings a mineral property through the four stages in the life of a mine i.e. prospecting, exploration, development and exploitation. Recently, reclamations has been added as 5th stage which is now considered as statutory obligation.

Prospecting :

Concerned with the discovery of minerals by geological investigations

Exploration :

Determining the economic aspects of the discovered mineral deposit and mining feasibilities

Development:

Making an access to the mine and creating infrastructures or capacity building

Exploitation :

Winning of minerals by designing of suitable method of mining keeping in view the economics, safety, environmental and societal objectives

Reclamation :

This is an important and latest mining activity which has been made mandatory in almost all countries. This includes post mining activities such as restoration of pre-mining site conditions and ensuring similar biological conditi*ons.*

In fact the terminology of **sustainable mining** is being frequently used these days and is being insisted upon by the society and the Govt. The objective is not only to make mining sustainable as well to maintain the healthy environmental conditions so as to be sustainable.

This includes:

- selection of suitable mining technology
- adoption of mitigating measures for the expected level of air, water and land pollution
- Not to disturb or to restore after mining the existing ecology, flora and fauna etc *so as to* preserve the same for future generation

Stages in the life of a mine:

Stage/ (Project Name)	Procedure		Time
1. Prospecting (Mineral deposit)	Search for ore a. Prospecting methods Direct: physical geologic 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, evaluate	*Precursors to Mining*	$1 - 3$ yr
2. Exploration (Ore body)	Defining extent and value of ore (examination/evaluation a. Sample (drilling or excavation), assay, test b. Estimate tonnage and grade c. Valuate deposit (Hoskold formula or discount method): present value = income − cost Feasibility study: make decision to abandon or develop.	*Precursors to Mining*	$2 - 5$ yr

Stage/ (Project Name)	Procedure	Time
	Mining Proper	
3. Development (Prospect)	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 yr

Stage/ (Project Name)	Procedure	Time
4. Exploitation (Mine)	Large-scale production of ore a. Factors in choice of method: geologic, geographic, economic, environmental, societal safety b. Types of mining methods Surface: open pit, open cast, etc. Underground: room and pillar, block caving, etc. c. Monitor costs and economic payback (3 – 10 yr)	10 – 30 yr
	Post-mining	
5. Reclamation (Real estate)	Restoration of site a. Removal of plant and buildings b. Reclamation of waste and tailings dumps c. Monitoring of discharges	1 – 10 yr

Stages and Schemes of Mineral Exploration:

- Favourable areas identified by prospecting must be delineated by exploration techniques
- once located the mineral deposits are sampled thoroughly and impartially and the samples analyzed for grades etc.
- the sampling data are utilized to prepare an estimate of tonnage with extent of deposit, as well grade from which the present worth of the deposit can be calculated and recommendations made regarding the economic feasibility of minin**g**

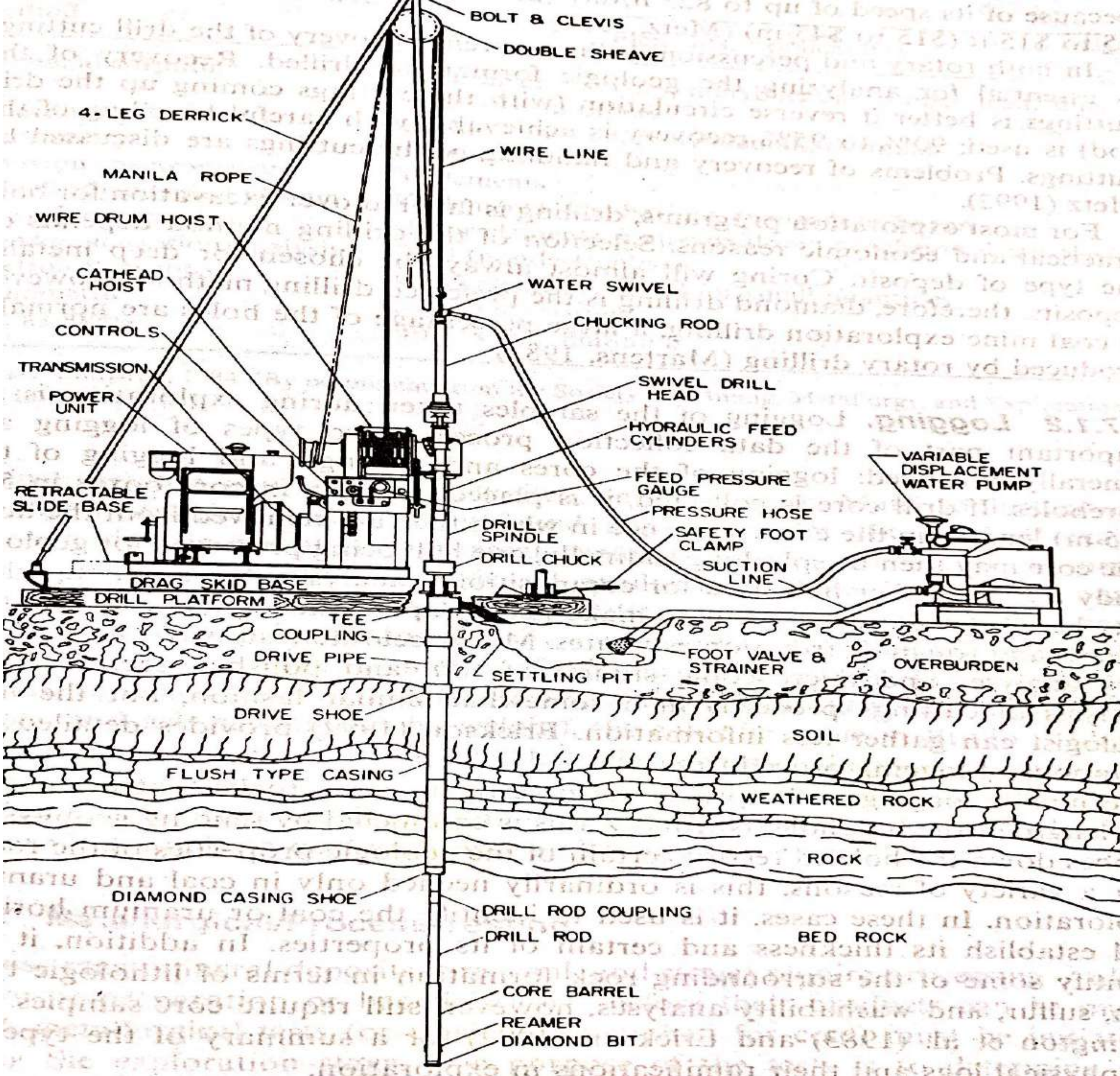
Resource: It is a concentration or occurrence of mineral in such a form and quantity that there are reasonable prospects for eventual economic extraction

A mineral **Reserve** is the economically minable part of a measured or indicated mineral resource that are economically minable at a given time**.**

It is to note that these two terms have the same relationship as mineral deposit and ore deposit: that is all reserves are resources just as all ore deposits are mineral deposits.

A reserve can become resource overnight if the market price for the mineral in the deposit drops suddenly.

Measured/Proved mineral reserve: That part of a mineral resource for which tonnage, densities, shape, physical characteristics, grade, and mineral content can be estimated with a high level of confidence. The data must be based on detailed and reliable information from outcrops, trenches, pits, workings, and drill holes. The location of the data points must be spaced closely enough to confirm geological and or grade continuity
Indicated Mineral Resource: That part of a mineral resource for which the tonnage, densities, shape, physical characteristics, grade, and mineral content can be measured with reasonable level of confidence. Data are gathered from similar points but locations are widely spaced to confirm geological and or grade continuity.
Inferred Mineral Resource: That part of a mineral resource for which tonnage, grade and mineral content can be estimated with low level of confidence. It is inferred from geological evidence and assumed but not verified.


BOLT & CLEVIS
DOUBLE SHEAVE
4-LEG DERRICK
WIRE LINE
MANILA ROPE
WIRE DRUM HOIST
CATHEAD HOIST
WATER SWIVEL
CHUCKING ROD
CONTROLS
TRANSMISSION
SWIVEL DRILL HEAD
POWER UNIT
HYDRAULIC FEED CYLINDERS
VARIABLE DISPLACEMENT WATER PUMP
FEED PRESSURE GAUGE
RETRACTABLE SLIDE BASE
PRESSURE HOSE
DRILL SPINDLE
SAFETY FOOT CLAMP
DRILL CHUCK
SUCTION LINE
DRAG SKID BASE
DRILL PLATFORM
TEE
COUPLING
DRIVE PIPE
FOOT VALVE & STRAINER
OVERBURDEN
SETTLING PIT
DRIVE SHOE
SOIL
FLUSH TYPE CASING
WEATHERED ROCK
ROCK
DIAMOND CASING SHOE
DRILL ROD COUPLING
DRILL ROD
BED ROCK
CORE BARREL
REAMER
DIAMOND BIT

Mineral Resources of India: The mineral sector is indisputably one of the fundamental strengths of the national economy, with its share of contribution to GDP and employment.

- The value of domestic mineral production was nearly Rs.58 crores only in 1947.
- Total value of mineral production (excluding atomic & fuel minerals) during 2017-18 has been estimated at 1.13 lakh crores with an increase of about 13% over that of the previous year.
- In 2015-16 the mining industry accounted for about 2.6% of the total gross value added (GVA). But going by GDP of industrial sector the mining industry contributes 10-11%.

- India produces as many as 95 minerals, which includes 4 fuel, 10 metallic, 23 non-metallic, 3 atomic and 55 minor minerals (including building and other materials). India has large reserves of:

• Coal,	• Manganese ore,
• Iron ore,	• Baryte,
• Bauxite,	• Rare earth and
• Chromium,	• Mineral salts etc

In 2015-16, there were more than 2,101 reported mines excluding atomic and minor minerals, natural gas and petroleum (crude).

Out of 2,101 reported mines about:

- 274 nos. of mines are located in Madhya Pradesh
- 252 nos. in the state of Tamil Nadu,
- 225 nos. of mines in Gujarat,
- 211 nos. in Jharkhand state,
- 162 nos. of mines in Chhattisgarh,
- 157 nos. of mines in the state of Odisha,
- 146 nos. in Karnataka state,
- 135 nos. in the state of Andhra Pradesh,
- 134 nos. in Maharashtra state and
- 100 nos. of mines in the state of West Bengal.

These 10 states together accounted for 85% of the total number of mines in the country in 2015-16. Among them, 558 mines belonged to coal and lignite, 668 to metallic minerals and 975 to non-metallic minerals.

Raw materials consumption per capita/year – 1.1 tonne

- Per capita value of Minerals produced- Rs.1680
- Value of raw materials produced/sq.km of land surface-
  : Rs.620,000

Mineral Production in India Vis a Vis Global Scenario

- India was the world's largest producer of mica blocks and mica splittings.
- India ranks 3^{rd} in the production of coal and lignite after USA & China,
- 2^{nd} in Limestone after China,
- 2^{nd} in Barytes and Chromite,
- 4^{th} in iron ore after China, Australia & Brazil,
- 6^{th} in bauxite and 5^{th} in manganese ore.

In terms of resource inventory Life Indices of major minerals are large and sustainability of the sector is assured in the long term:

- For coal, the life index is >200 years;
- for bauxite it is >204 years;
- for iron ore it is >105 years;
- for chromite it is >47 years;
- for manganese ore it is >113 years, and
- for limestone it is >360 years.

Total Mineral Resources in India:

Mineral	Million Tonnes	Location
Coal (As on 1.4.2014)	301564	Jharkhand(27%), Odisha(25%), Chhattisgarh (17%), West Bengal(10%), Madhya Pradesh (8.5%), Telangana & AP(7.5%), Maharashtra (3.6%). Also present in UP, Meghalaya, Assam, Nagaland, Bihar Sikkim & Arunachal Pradesh
Bauxite (As on 1.4.2005)	3290	Major deposits are concentrated in the East Coast Bauxite deposits of Odisha and Andhra Pradesh. Also found in Gujarat, Chhattisgarh, Madhya Pradesh, Jharkhand and Maharashtra
Chromite (As on 1.4.2005)	231	95% in Orissa(Sukinda valley in Cuttack), balance in Manipur and Karnataka and meagre quantities in the states of Jharkhand, Maharashtra, Tamil Nadu and Andhra Pradesh.
Copper (As on 1.4.2005)	1390 (369.49MT Of Metal)	Rajasthan,Madhya Pradesh and Jharkhand. Also present in AP, Gujarat, Haryana, Karnataka, Maharashtra, Meghalaya, Odisha, Sikkim, Tamil Nadu, Uttarakhand and West Bengal.

Mineral	Million Tonnes	Location
Gold (As on 1.4.2005)	390.29 Ore 490.81 Metal	Karnataka remained on the top followed by Rajasthan, West Bengal, Bihar and Andhra Pradesh.
Iron Ore (As on 1.4.2005)	17882	Odisha(33%), Jharkhand(26%), Chhattisgarh (18%), Karnataka(12%) and Goa-(5%).
Lead Zinc (As on 1.4.2005)	522.58 Ore 0.0072 Lead 0.0243 Zinc	Rajasthan, Bihar, Maharashtra, Madhya Pradesh, Andhra Pradesh, Gujarat, Uttarakhand, West Bengal, Odisha, Sikkim, Tamil Nadu and Meghalaya.
Diamond (As on 1.4.2005)	4582 thousand Carats	Panna belt in Madhya Pradesh, Andhra Pradesh(Kurnool district, Anantapur district, Krishna river basin)and Raipur, Bastar and Raigarh districts in Chhattisgarh.
Limestone (As on 1.4.2005)	175345	Karnataka is the leading state followed by Andhra Pradesh, Gujarat, Rajasthan, Meghalaya, Chhattisgarh, Madhya Pradesh, Odisha, Maharashtra and Uttarakhand.

Economic Importance of Mining:

- No nation can achieve a high level of prosperity without a reliable source of minerals to supply its manufacturing industry.
- The uniqueness of mineral deposits largely depends on the complexity of mineral economics and individual mining enterprise.
- Minerals are immobile whose production is restricted to the locality in which it occurs,
- A mineral deposit can be viewed as a depleting or wasting asset and unlike agricultural or forest products, cannot reproduce or be replaced.
- Because its mineral assets are continually being depleted, a mining company must discover additional reserves or acquire them by purchase to stay in business.
- These factors impose limitations on a mining company in the area of business practices and financing as well as in production operations.

- Production costs tend to increase with the depth of the mine and increasing input costs.
- Similarly, declining grade of ore is adversely affecting financial viability with which every mine eventually is confronted. So technological upgradation plays a key role in the mining industry.
- Financial hazards are great because of change in volume and grade of ore produced, mining cost, input costs, price of import substitute of ore/ metal. As such, Viability may be extremely difficult to assess in a dynamic market scenario.
- Because of great financial risks, however, it is always expected that return on an investment should be higher and the payback period should be shorter in a mining enterprise.
- Largely, mineral properties as well as mines are marketable.

Definition of a Mine: As per Mines act 1952

Mine means any excavation where any operation for the purpose of searching for or for obtaining minerals has been or is being carried on and includes

i. all borings, bore holes, oil wells and accessory crude conditioning plants, including the pipe conveying mineral oil within the oilfields:

ii. all shafts, in or adjacent to and belonging to a mine, whether in the course of being sunk or not:

iii. all levels and inclined planes in course of being driven;

iv. all conveyors or aerial ropeways provided for the bringing into or removal from a mine of minerals or other articles or for the removal of refuse therefrom;

v. all adits, levels, planes, machinery works, railways, tramways and sidings in or adjacent to and belonging to a mine;

vi. all protective works being carried out in or adjacent to a mine;

vii. all workshop and store situated within the precincts of a mine and the same management and used primarily for the purposes connected with that mine or a number of mines under the same management;

viii. all power stations, transformer sub-stations converter stations : rectifier stations and accumulator storage stations for supplying electricity solely or mainly for the purpose of working the mine or a number of mines under the same management;

ix. any premises for the time being used for depositing sand or other material for use in a mine or for depositing refuse from a mine or in which any operations in connection with such and refuse or other material is being carried on, being premises exclusively occupied by the owner of the mine:

x. any premises in or adjacent to and belonging to a mine or which any process ancillary to the getting, dressing or operation for sale of minerals or of coke is being carried on;

xi. all opencast workings which means a quarry, that is to say an excavation where any operation for the purpose of searching for or obtaining minerals has been or is being carried on, not being a shaft or an excavation which extends below superjacent ground

Surface Mining Vs Underground mining:

After ascertaining the presence, extent and economics of the mineral deposit it is to be decided whether it will be worked by surface mining or by underground mining.

- Shallow deposits are extracted by surface mining or opencast mining methods. In this method, the overburden (i.e. the material lying over the deposit) is removed to expose the mineral, which is then extracted.
- But if the depth of the deposit is such that removal of the overburden makes surface mining uneconomical, underground mining methods have to be used.

MINE DEVELOPMENT:

Mine development essentially involves driving **primary and secondary** openings so as to reach the mineralized zone and make it amenable by suitable method of extraction. It may be noted that the development layout depends on the method of extraction. A considerable length of development drivage is required before a deposit is finally extracted.

Primary Development: The primary development drivages are done primarily to provide an access to the orebody from the surface. This serves:

- to provide access to the mineral deposit,
- to provide transport for men, material and the mineral,
- to carry air for the ventilation of the underground workings for men and machines.
- To accommodate pipes and cables leading to the underground workings
- for transmission of compressed air, power, water and backfilling material i.e. sand etc.

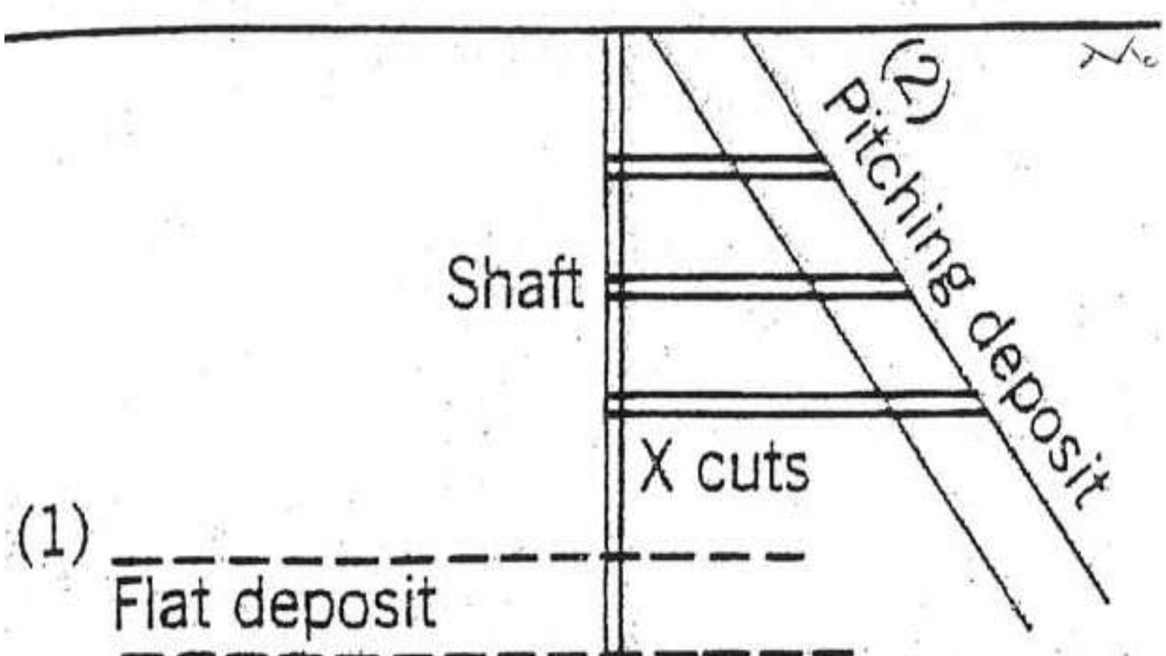
Secondary Development: Secondary development openings can be driven within the deposit, as in practice in flat - lying coal seams (e.g., drifts, entries, crosscuts), or outside the deposit, as is generally practiced in three – dimensional ore bodies in metal mines (e.g., adits, tunnels, drifts).
These supplements the main entries and serves the same purpose.

Mine Entries: Following Mine Entries are normally excavated for making access to the ore body:

- Vertical shaft or
- Inclined Shaft or
- Adit or
- Slope/Incline/Decline

Vertical Shaft: It is a vertically downward excavation of circular cross section suitable for skip winding. It is normally sunk for

- Deep flat deposits(<30^0)
- Steeply Inclined(>70^0)
- Bad Natural Condition
- Moderate Production Capacity because of cyclic vertical transportation
- Long life

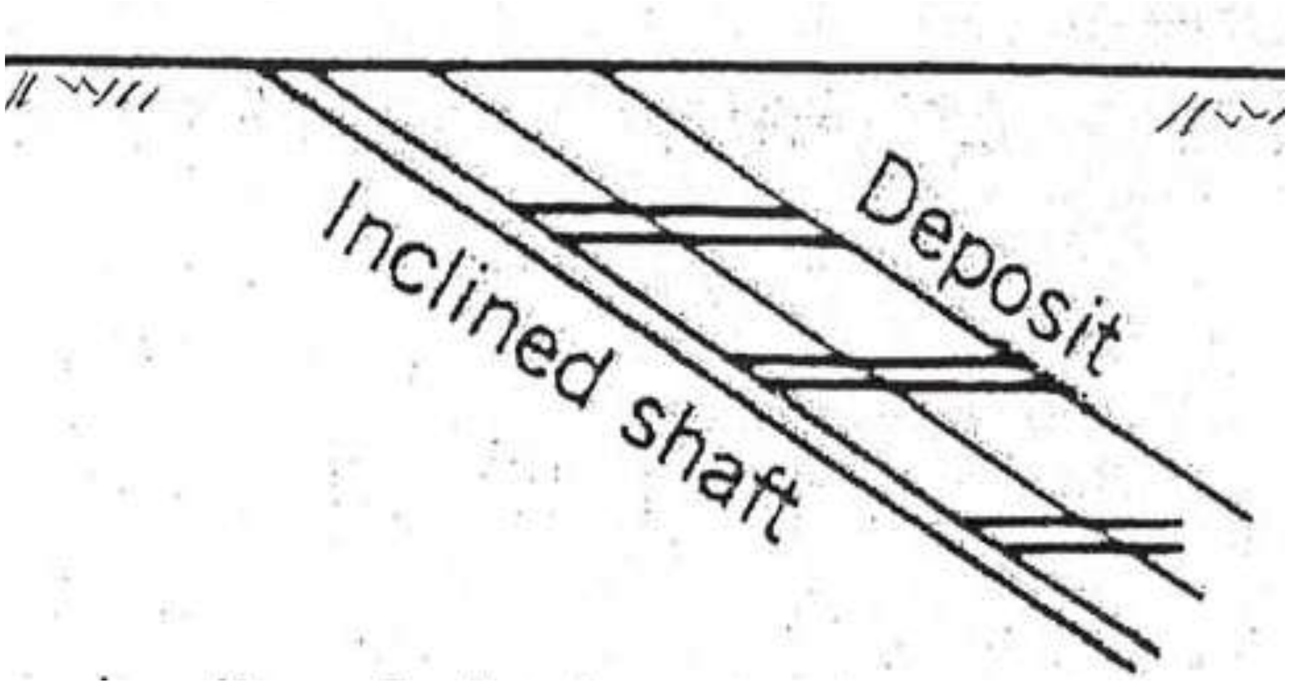


Shaft with hoisting

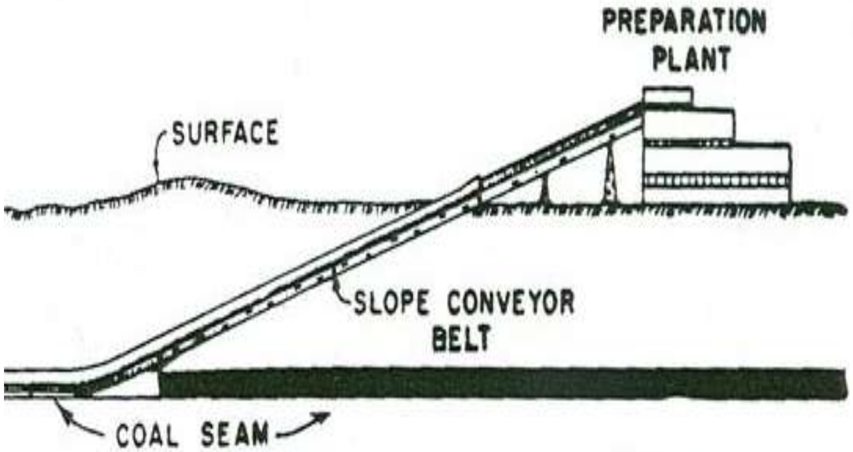
Inclined Shaft:

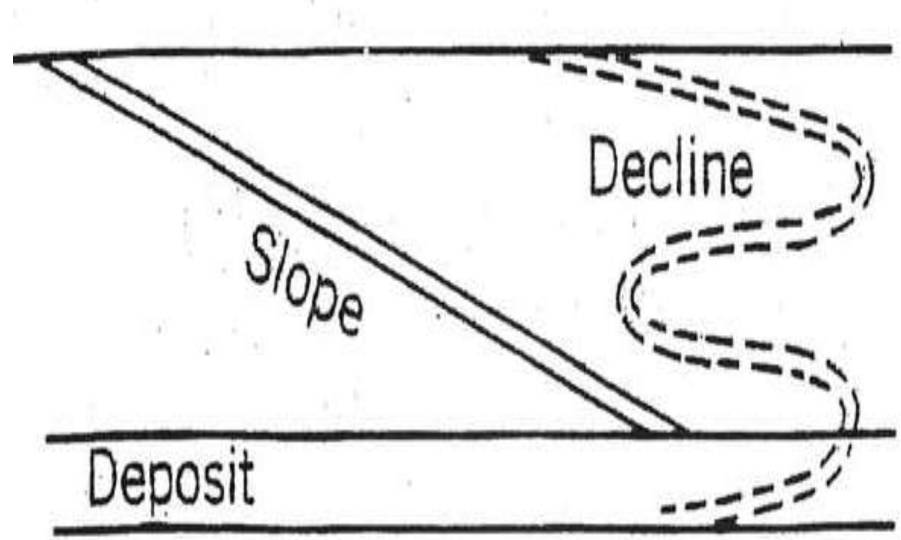
Characteristics:

- Excavation of normally rectangular cross section with haulage-tub combination or even with skips in steep shafts
- Moderately inclined deposit(30^0 to 70^0)
- Moderate Production Capacity because of cyclic transportation on steep slope
- Moderate mine life
- Less horizontal development
- Exploration is also possible during drivage



Slope or Decline:

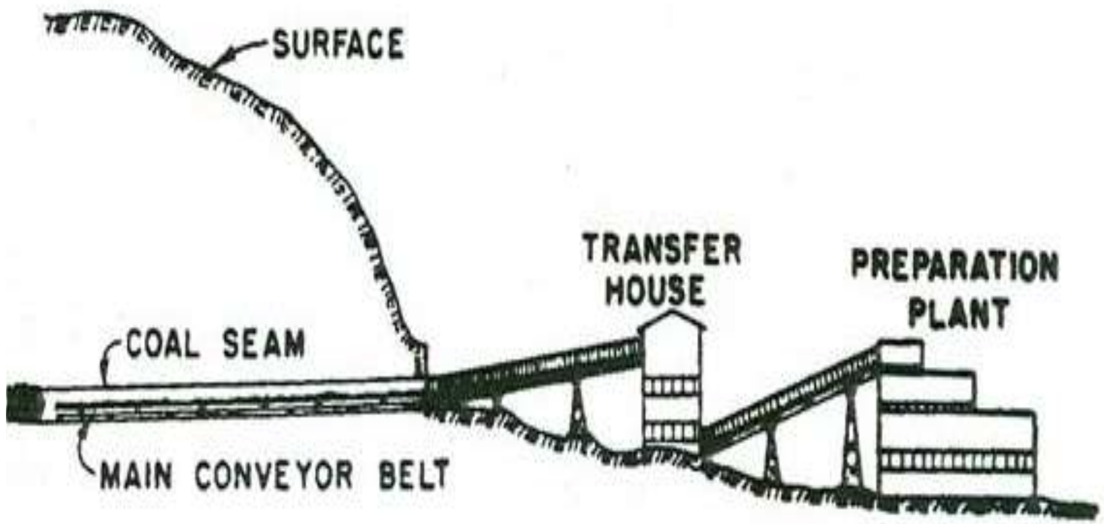




Characteristics:

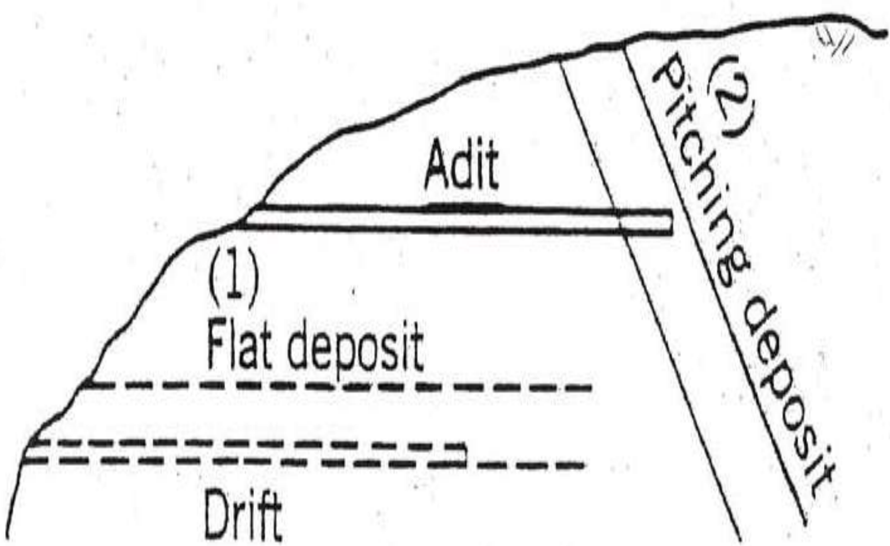
- Excavation of normally rectangular cross section
- Suitable for shallow to medium depth deposit
- Long life
- Trackless and noncyclic continuous mining is possible in straight slopes. As such, **high production** capacity mine can be built up with conveyors installed at 16%(9.1$^{0)}$ gradient.
- In declines even trucks can be deployed at a gradient of 12 to 14%(6.8^{0} to 8^{0})

Adit or Drift:



Characteristics:

- Hilly terrain
- Level drift from foot of hill to intersect the deposit
- Outcrop above loading level
- Sufficient space available at mouth of adit for surface infrastructure
- Cheapest mode of entry
- Can be equipped with locomotive haulage(cyclic) or conveyor(non cyclic) for high Production capacity



Vertical Shaft Vs inclined shaft:

The main deciding factors are:

(i) type of mineral deposit and
(ii) depth of the deposit.

- For coal or other flat-lying formations, generally the depth is the deciding factor. When an ore deposit lies at a depth not exceeding 300-400m, **Inclines/slopes** are usually driven.

- But at greater depths, **Shafts** are the usual choice.

- If the ore-body is vertical or very steep, obviously **Vertical Shaft** is a natural choice. We can have the shaft in the ore body itself if the ore body is strong because shaft has to be a stable and long lasting. But this may lock up a lot of the mineral for the protection of the shaft.

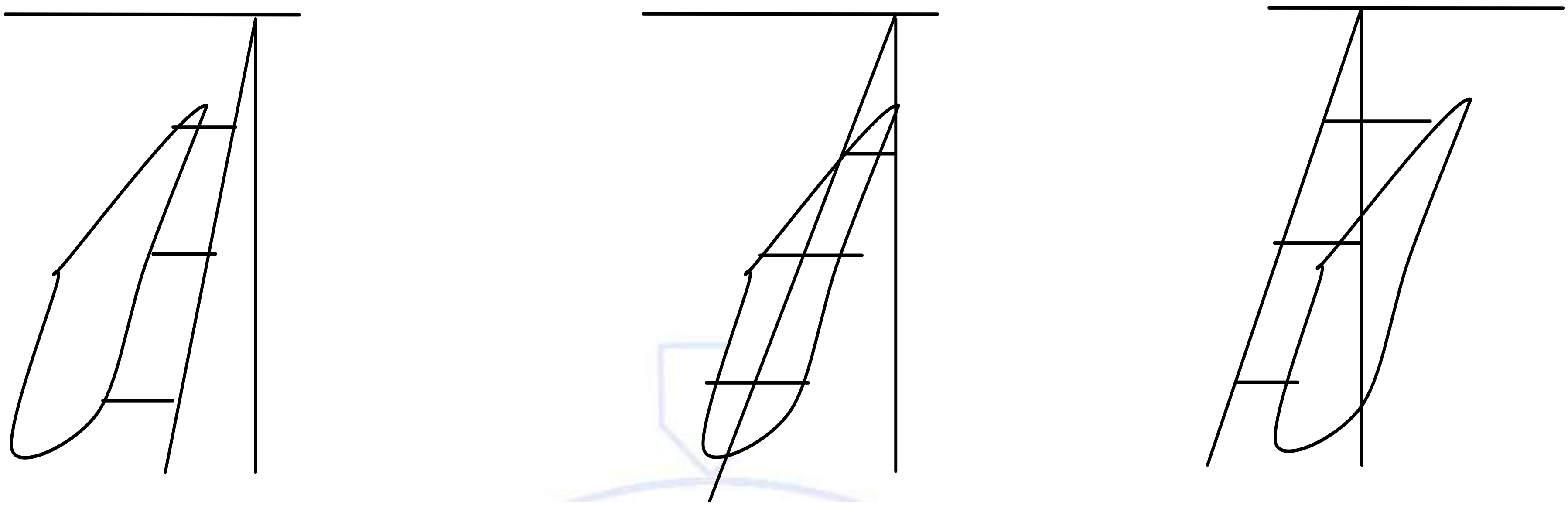
- For inclined deposits, the choice will depend upon the dip of the ore body. **Vertical Shafts** require cross-cuts to be driven to the ore body. As such, at a greater depth the total length of the cross-cuts increases as the depth of the shat increases.

- So, to minimize the aggregate length of the cross-cuts we can sink a inclined shaft in the footwall parallel to the ore body. such a shaft has the advantage of short length of x-cuts, stable, quick access, less expenditure on the short x-cuts

- If the deposit has a uniform dip, the vertical shaft should intersect the deposit at half the ultimate depth of the mine so that the aggregate length of the X-cuts is the shortest. (Say 500 m is the ultimate depth – shaft should intersect the vein at 250 m depth). In this case the upper part of the shaft is in the hangwall but extraction of the ore body may damage the shaft. Because the shaft has to last till the full life of the mine. So, we have to keep a safe margin between the workings and the shaft or we have to adopt a suitable method of mining so that the shaft is not affected by the workings.

- When the dip of the ore body is not uniform the inclined shaft can not be parallel to the orebody because this will reduce hoisting capacity and increase the cost of operation. For the most economical hoisting, inclined shafts should be straight. A few bends of slight curvature may not have serious effects but a shaft cannot afford to follow the deposit of irregular dip.

Location of Vertical or Inclined Shaft:



For Choosing between a vertical and a inclined shaft, the overall economy has to be worked out.

- Generally, inclined shafts are used for inclined ore bodies(30^0 to 70^0).
- Beyond 70^0(between 70^0 & 90^0) vertical shafts are more economical.
- An inclined shaft is larger in length hence costlier and requires more maintenance. The production capacity of a mine with inclined shaft is having 25% less than that with a vertical shaft of same cross section.
- The latest trend is to sink vertical shafts for obvious advantages of efficient winding with optimal capex and opex.

VERTICAL SHAFTS VS SLOPES/INCLINES:

Important Parameters For A Mining Project	Shaft	Inclines
Time requirement for completion	More	Less
Capital cost	More	Less
Continuous transport of mineral	Cyclic	Continuous
Capacity of ore/coal transport	Moderate	Large
Operational cost	More	Less
Resistance to ventilation	Less	More
Length of cable, pipeline	Less	More
Possibility of uncertainty Impacted by geological factors	Less	More
Loss of coal in protective pillar	Less	More
Environmental problem	More	Less

Classification of Mining

Broad Classification	Class	Method		Applicable to Coal/Metal/ Non-Metal
Traditional Mining:				
Surface	Mechanical	Open Pit Mining		Metal, Non Metal
		Quarrying		Non Metal
		Open cast (strip) mining		Coal Non Metal
		Auger Mining		Coal
	Aqueous	Placer	Hydraulicking	Metal, Non Metal
			Dredging	Metal, Non Metal
		Solution	In Situ Techniques	Metal, Non Metal
			Surface Techniques	Metal
Underground	Unsupported	Room and Pillar mining		Coal, Non Metal
		Stope and Pillar mining		Metal, Non Metal
		Shrinkage Stoping		Metal, Non Metal
		Sublevel Stoping		Metal, Non Metal
		Vertical Crater Retreat mining		Metal, Non Metal
	Supported	Cut and Fill stoping		Metal
		Stull stoping		Metal
		Square set stoping		Metal

Broad Classification		Class	Method	Applicable to Coal/ Metal/Non-Metal
Underground		Caving	Longwall Mining Sublevel Caving Block Caving	Coal, Non Metal Metal Metal
Novel Mining:				
			Rapid Excavation Automation, Robotics Hydraulic Mining Methane drainage Underground Gasification Underground Retorting Marine Mining Nuclear Mining Extraterrestrial Mining	Non Coal(Hard Rock) All Coal, Soft Rock Coal bed Methane Coal Hydrocarbons Metal, Non Metal Non Coal Metal, Non Metal