U/G Metal Mining

Every mine other than coal & oil mine.
An ug mine in its early stage requires a carefully planned ntw of shafts and raise to enable
(i) nature of country rock, strength of ore.
(ii) Permits Prospecting to be carried out.
(iii) Provides access and transport facilities for man & material and ventilation operation. etc.

Terminology :-

Mineral :- Mineral is a naturally occuring substance having definite chemical composition & physical structure.

Assay :- To determine the mineral content or metal content in an ore sample.

Ore :- A naturally occuring solid material from which a metal or valuable mineral can be extracted Profitably.

Ore Pass :- Any passage which is made for transport of booken ore in stope is known as ore pass

Breast hole :- when the blasting hole is made in front of a face such a hole is known as breast hole

Breast stoping :- when breast holes are used for the extraction of stope. Such stope working is known as breast stoping.

Country rock :- The country rock of an ore body is that rock which is predominant in the area and which contains the ore body. The country rock forms the foot wall and hanging wall.

Cross-cut :- a horizontal drivage from the shaft driven to meet the ore body is known as cross cut

Face :- The moving front of any working place is known as face.

→ Level ÷ Approach to ug mineral beds and ore bodies at depth is first by vertical or inclined and then from such shafts by horizontal passa
→ over-burden ÷ valueless rock covering the mineral deposit.
→ raise ÷ A connection betn two levels in an ore body driven in an upward dirn.
→ winze ÷ A connection betn two levels in an ore body driven in downward direction.
→ crown pillar ÷ A pillar of insitu ore in mine support the level above it.
→ foot wall ÷ The wall of rock on the under s of a vein is called foot wall.
→ Hanging wall ÷ The wall or rock on the upper of an inclined vein.
→ Drift ÷ when the drivage is made in the rock across the two veins it is known as drift
→ sub level ÷ It is a horizontal drivage betn two adjacent levels, that connects the two adjacent raises and winzes.
→ main level ÷ It is a level which is used as haulage level for the transport of ore.
→ stope ÷ It is a solid ore block or ore pill which is under extraction is known as stope.
→ stoping ÷ It is the operation of extraction of solid ore block or ore pillar is known as sto
→ staple pit ÷ (Blind Pit) ÷ is a vertical pit, f an ug working place to another ug working place but does not extend up to surface.
→ Cross cut ÷ A cross cut is a horizontal ug passage way that provides access to mining operation and is usually bored from mining shaft at near right angl to strike of ore body.

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→ Diff^n b/w Coal mine & metal mine :-

→ Coal is a bedded deposit, but however most of metalliferrous minerals are ~~however~~ non-bedded type with exception of limestone, potash, salt, iron, phosphates.

→ Coal is softer than most of the metalliferrous minerals and coal drilling are therefore electrically operated, as electricity is the Power in coal mine, where as compressed air is the main power in underground metal mine.

→ Coal can be used directly after extraction from the mine as a fuel. but all metallic minerals need to be processed for getting mineral & metal.

→ U/g coal mining is much simpler; after vertical shaft touches the coal seam, the road can be made in the coal seam itself producing coal in the process of drivage of roads. but in metalliferrous mining standard practice requiring drivage of roads in the footwall and the country rock to reach the ore body.

→ U/g coal mines produces an inflammable & explosive gas, fire damp. but such danger does not exist in u/g metal mines. so naked safety flame lamps can be to taken in coal mine, where it can be used in metal-mines.

→ sampling and assaying are important day to day operations in metalliferrous mining during development stage. but in coal mining does not call for a regular sampling and quality control.

→ metal mines require high standard of surveying but in coal mine where in-seam mining is practised a slight error in surveying will not disturb the mine working.

→ In metal mining, it requires almost details exploration & careful planning before opening up a mine.

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in ufg mine it requires almost 4-5 yr. for start of production but in coal mine it is relatively easy.

Level interval :- the vertical distance betn two levels is known as level interval. level driving is a narrow work involving more cost per m than stoping. Each level requires timbering, haulage track, pipeline, loading machines and hauling machines.
During lateral development in a metalliferous mine the interval betn the levels varies from 15m to 100m depending up on the following factors.
(1) Cross cuts, drifts etc
(2) Nature of rock, dip, their quality. etc.
→ thicker the ore body, lesser is the level interval and if the ore body is thin, then the level interval is more: because in thick deposit there is sufficient supply of ore betn near levels. also the pressure in stoping would be great in thick deposit, so that the level has to be mined out quickly.
→ Raising method in metal mines :-
Raising is a regular operation in development of metalliferrous mines. the supply of material, ventilation haulage from the upper level to the lower level or reverse is not possible and the difficulties are also faced. Hence during the development of ore body it is necessary that interconnection betn the two levels are made by from main haulage level.
The methods practise in raisings are

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1) Open raising method :- This is a simple & most common method adopted in majority of the metal mines.
- The workers stand on a platform made of timber planks supported on boom bars fitted in to the footwall. The clamps used for supporting platform are made in standard length of old rails.
- The drilling of holes for blasting is by jack hammer and generally followed by wedge pattern & burn pattern. The hole dia is generally 32 mm and 1.5 m deep.
- Before each round is blasted the platform is dismantled immediately after blasting compressed air is forced to the working faces by opening valve of the air pipe to remove the fumes of blasting and for ventilation.
- In longer raises sometimes a blower with a flexible air duct is installed. Access to faces is by ladders made of wood, tubular steel or rope.
- It is conveniently adopted for raises of moderate lengths up to 8m and inclination of 45° - 60° and coal rocks are strong enough so artificial supports are not required.
- The working platform is advanced regularly so as to maintain necessary head room at the face. The broken rock rolls down by gravity and placing ladders and pipes on footwall and sides respectively is very convenient.
- Careful checking and dressing down of loose rock by skilled workers before allowing workers to go up is essential.

Disadvantages :-
- Lack of ventilation.
- Damage to pipes and ladders from blasting.
- Loss of efficiency when the raises go higher as the workers have to frequently go up and down the ladder.

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1) Two or three compartment method :-

→ This method of raising is adopted for vertical and very steep raises only.

→ After initial excavation from lower level in the dir of raise for 3m the raise is divided in to 2 or 3 compartments and move in forward dirn.

→ one side of lower level three posts are set in the rais. The two end posts are at two corners of raise and post is at halfside.

→ one of the compartment is used for loading. It is provided with loading chute is lower level. The other compartment is used as ladder way, compressed air pipe, ventilation pipe the blasting cable are carried in this compartment.

→ During working the top of compartments are kept covered with thick wooden sheet steel platform. The platform has window for workers and carrying pipes and cables.

→ only in half area of raise the holes are drilled. They are charged and connected to blasting cable. the pipes and lights are lowered below the platform The shotfirer comes the last closing the window. The holes are blasted from the lower level. The ventilation is resumed.

→ After 10 - 15 minutes the raise is inspected. The window is slowly opened. The workers get top of the platform. The blasted area is dressed and the blasted rock shovelled to ore pass and loaded in the lower level. through loading chute.

→ The holes are then drilled in the other half. area of raise. The holes are charged and blasted as the previous way.

→ The posts are further extended. and again the blasting work of raise is carried in two parts, as described.

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→ In 3 compartment method, the area initially divided in two, one area used as ore pass, the second half area is farther divided in two parts.
→ one part is used as ladder way and other used for conducting the pipelines and cable. The drilling blasting and removal of blasted material of the raise are carried in the same way.

→ Jora Raise lift :
→ Raise driving by the use of Jora Raise lift was probably the first approach towards mechanised raising up to 100m long raises. Many improvements have been made on this method of raising with in last decades and the method is now not being used.

Long hole raise drive :
→ In this method of raising long hole drilling, loading and blasting operations are performed from horizontal workings and no need of miner's presence at the face.
→ the drilling holes are marked at 1m to 1.5m distances. These holes are drilled by special jumbo raise drill or other similar type of drill. The dia. of the hole is 50mm to 75mm. the length of the hole is from upper level to lower level.
→ The holes are parallel to centre hole. The centre hole is an additional hole. the dia. of the centre hole is increased to 100mm to 125mm and the centre hole is always uncharged.
→ The other holes are charged with explosive up to 1m length. wooden wedges are fitted in the end of hole opening in lower level. The charge of explosive carries a priming cartridge fitted with detonator. the detonator has very long leading wires so that the leading wires can be easily connected with blasting cable in the upper level.

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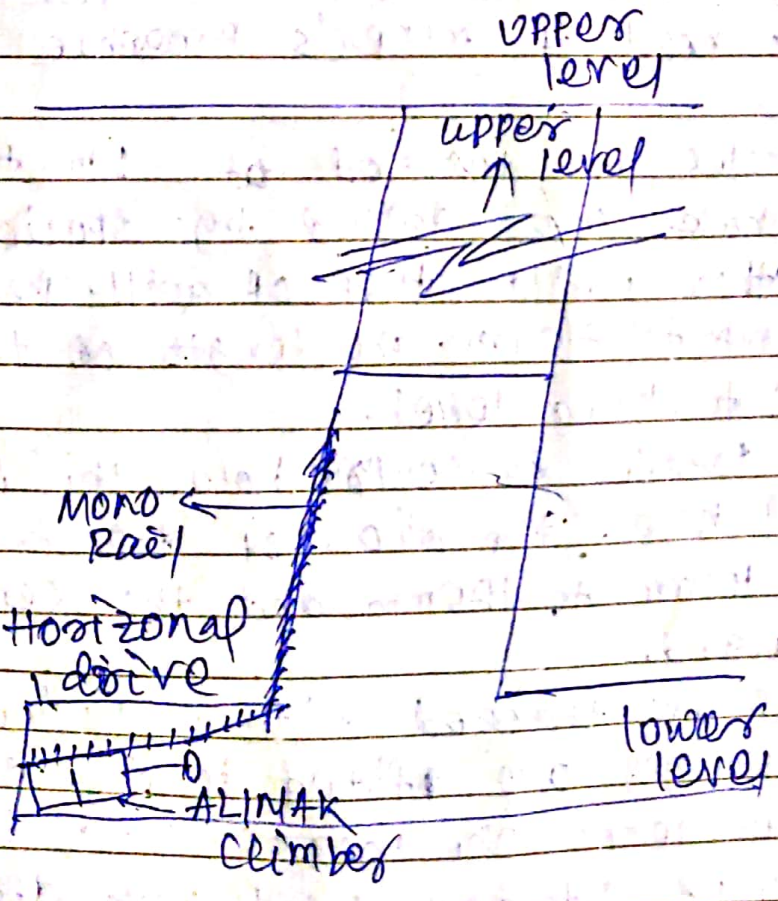
→ The hole is stemmed with stemming material up to 2m length above explosive charge of the hole. Two locking wedges will seal the hole above the stemming. All the holes are similarly charged & stemmed and the centre hole is kept open.

→ The blasting of the hole is carried out when all the workers are removed on the surface.

→ Every time the raise is blasted up to 3m length. The blasted material is removed each time. These operations are repeated till the drivage of raise is complete from lower level up to upper level.

→ Alimak Raise climber :-



Alimak climber

→ It consists of a climber, which has two compartments one above the other. They are constructed in thick steel sheet. The lower compartment is for the workers to side in, the upper compartment is provided with compressor.
→ There are covers in the lower & upper compartment. The workers can move from lower to upper compartment and the top of upper compartment.
→ On the top of upper compartment there is a provision of extensible small platform and a strong steel canopy set.
→ The canopy has a side gripper so that it can move on mono rail.
→ At first from the lower level wedge cut holes are drilled on the one side of the centre marked in the lower level. The length of the drivage is 10-15m.
→ The holes are charged, connected and blasted from safe distance. Then other side of the centre marked is drilled and blasted in the same way.
→ The blasted broken material is removed and holes are drilled in the side of small gallery and in the rise side of the raise.
→ In these holes the expasion bolts are set firmly. and on these bolts the mono rail is set.
→ The mono rail is set in rising from mid height to the roof of the raise. The Alimak raise climber is set on the mono rail. The climber moves on the mono rail when it is operated provided by a motor.
→ The climber stops at the end of the mono rail. The workers riding in the climber climb on the top of the upper compartment of climber.
→ They stand on the strong canopy and extend the strong platform and fix it. The take out right

and drill machine with compressed air connected hose pipe. They stand under the canopy & drill the holes.

→ The holes are charged & connected with the blasting cable. The workers withdraw the light & drill.

→ They come in the compartment after withdrawing the platform. Then they take the climber to the lower level at the safe side before blasting and charge the hole after safe arrival.

→ The blasted material falls down on the floor of lower level. The ventilation is resumed the gases and smokes are cleared. The material fallen in lower level due to gravity is loaded in tubs in lower level. It is transported.

→ When smokes are cleared the workers ride in the climber. It is operated. It travels up to the end of mono rail. and they dress the blasted area.

→ They drill the holes in the rise side of the rails for expansion bolts. and mono rail is further extended. The climber is again operated to reach the roof of the raise.

→ All these operations are cycled till the drive of raise is completed.

Advantages :- 1/ The material falls due to gravity in lower level. 2/ Loading of material in lower level is quick. 3/ Much of time is saved by climber as workers are riding in it. 4/ No ladder ways pipelines etc. are required. 5/ Dressing is safe under canopy. 6/ Platform is not damaged. 7/ cycle time is short. 8/ It is quick method. a/ suitable for vertical & Incline raise.

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Stoping :- Stoping is the final extraction of an ore body that has already been developed.

→ The main work consists of drilling and blasting of ore, removal of the broken ore from working place and supporting the ground so that the operation can be carried out safely.

→ Various methods of stoping are adopted for diff^n types of ore deposits. The choice of method of stoping depends up on the following factors.

(1) shape, size and thickness of the ore body.
(2) Mineralogical character & value of ore.
(3) Dip of the ore body.
(4) character of the ore body.
(5) character of walls.
(6) cost of ore body.
(7) cost and availability of support material.
(8) Dilution of ore with waste.
(9) Depth below surface
(10) nature of OB.
(11) Continuity of the ore body.

Classification of stopping method :-

1) Stopes naturally supported :-
(i) open stopes in small ore bodies.
(ii) sub level stoping.
(iii) Room & pillar.

2) Stopes artificially supported :-
(i) shrinkage stoping.
(ii) cut & fill stoping.
(iii) Square set stoping.

3) Caved stoping :- (i) Block caving.
(ii) sub level caving. (iii) TOP slicing.

4) ~~Combination of supported & caved stopes :-~~

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→ Open stope :- → An open stope is which no filling or timber is used to support walls and only simple form of scattered timbering is used as support.
→ the walls are sometimes supported by temporary or permanent pillars of ore and therefore is applicable to low grade ore bodies of not higher cost.
→ Both wall rock and ore should be strong. Open stoping permits of drilling, loading & hauling. Dilution of ore is min^m.
→ Open stopes in small ore bodies are further classified in to 3 types.
1) overhand stoping 2) Underhand Stoping 3) Breast stoping
the terms "overhand", "underhand" and "breast" as applied to stoping refer to the situation of the face w.r.t to the driller.

1) Overhand stoping :-
→ Conditions :- 1) The thickness is selected up to 4.5m.
2) The ore body required is strong.
3) Both hanging wall & foot wall are strong.
4) The inclination of ore body is bet^n 45° to 90°.

Stope working :-
→ In this method the overhand benches are formed. The height and width of benches formed are 1.5 - 2.5m. The length of benches will be equal to the width of ore body.
→ the holes are drilled in the benches are upward holes. The length of holes is equal to inverted height of the bench. The stoping operation proceeds from lower main level towards the upper main level and the ore is extracted in step like tales or benches in an ascending order.
→ The lower benches are driven ahead of the upper ones. The horizontal slices are taken in the haulage level.
→ chutes for broken ore are constructed so that the

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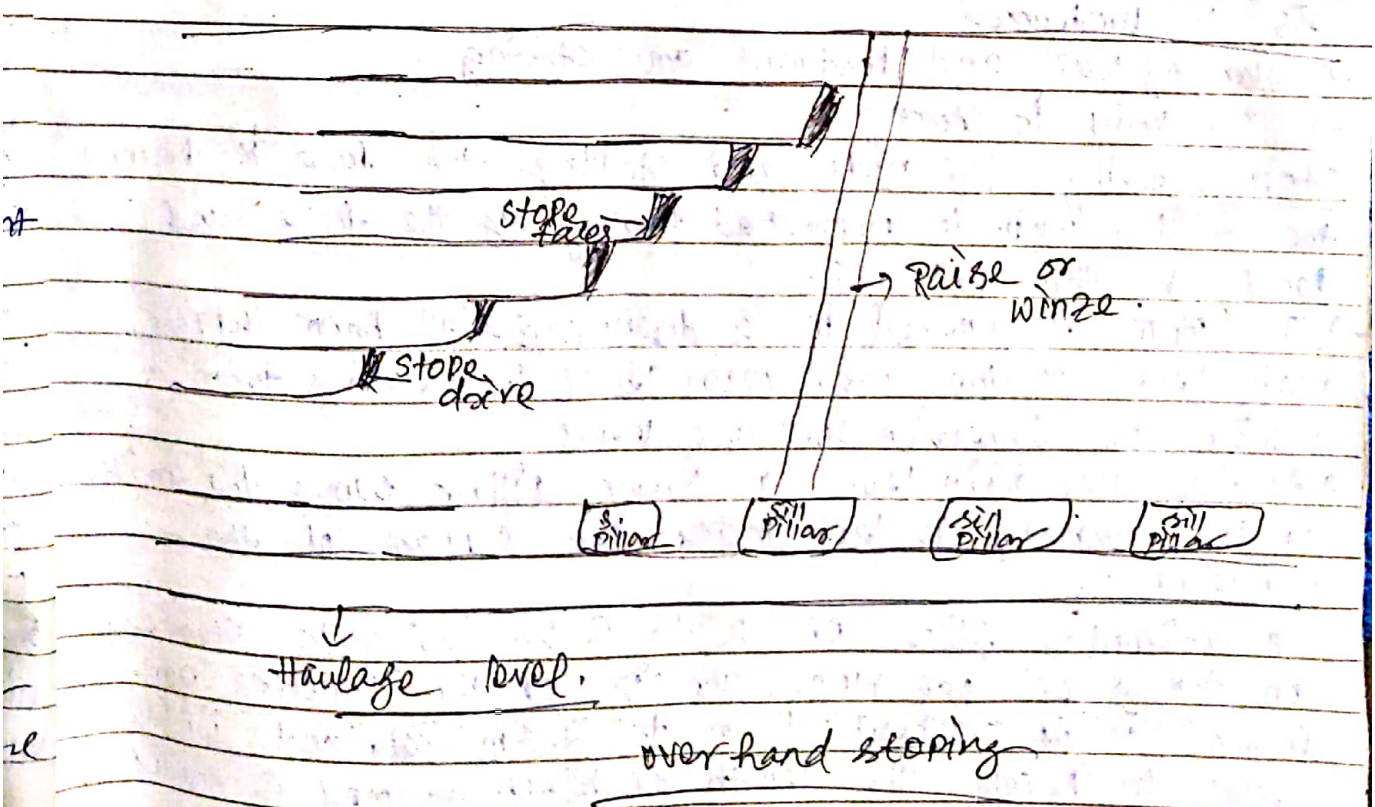
ore falls to the haulage level which is protected by a pillar of solid ore called sill pillar.

→ Strong ore and stable wall rocks are essential and the method is commonly employed in steeply dipping narrow veins deposits.

→ The ore drilled by compressed air drills and then blasted, gravitates along the foot wall and loaded in to tubs or mine cars through draw points equipped with chutes.

→ Sill pillar left above the haulage level is 2.5-3m thick and it protects the lower haulage level. Stoping operation is started by drivage of an undercutting level below the sill pillar, starting from raise. ore chutes are provided 5-7m apart.

Rill stoping: This is considered a form of overhand stoping where the excavation of ore is in inclined slices. The longitudinal section looks like an inverted V with an inclined back.



overhand stoping

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~~ii) under hand stoping :~~

→ Advantages :- (1) The worker stand on platform to work the back of bench. 2) the full advantage of gravitional force is taken in blasting.
3) The blasting efficiency is high.
4) Booken ore fall away from face.
5) the face is clear and the fall can be completely dressed. 6) ventilation is good.
7) There is no jamming or less jamming in loading chute.

→ Disadvantages :-
→ Drilling is troublesome.
→ Muck falls on the body of the worker.
→ the Booken ore can not be stacked in the stope.

→ underhand stoping :- Conditions :-
→ this method is suitable for thin ore body, thickness is not more than 1.5 m.
→ Inclination of ore body is more, inclination 45° to 85° is preferred.
→ Hanging wall and footwall are strong.
→ ore body is strong.

Stope working :- → In underhand stoping the face is below the driller who is supported partly by the face and partly by the footwall.
→ The stope is worked in a downward direction from upper main level to the lower main level commencing from a winze or connection between two levels.
→ At the upper main level a crown pillar along the strike of the orebody is left insitu for support of the mainlevel.
→ A horizontal slice of 2 to 2.5m high is started on top of an ore block. The size of the benches are formed is of height 1.5m to 2.4m and width equal to height. The length of bench formed is equal to thickness of ore body.

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→ one row of downward holes are drilled on either side of centre raise: The distance of hole from the centre raise is kept 1-2 m and no. of holes in a row are 2 to 5 depending on the thickness of the ore body. These are charged and blasted.
→ The blasted ore is ~~sto~~ transferred in the centre raise. It acts as an ore pass. The blasted ore is loaded in lower level through the chute for further transport. The first bench is formed.
→ The stulls are set at the floor level or upper level. These stulls are ~~set~~ covered with thick planks to form Plat form.
→ The holes are made from top bench in the upper level to lowest bench near the centre raise. These holes are charged with explosives and blasted. Blasted ore is shovelled in the ore pass. The top bench is extended and the 2nd bench is formed. The stulls are set and plat-form further extended.
→ In this way from upper main level to lower main level the inverted benches are formed and stoping is done.

Advantages:- (i) The workers are standing on strong and solid ore body. (ii) The machines are kept on the ore body. (iii) Drilling operation is easy. (iv) Faces can be dressed easily. (v) Faces are easily approached.

Disadvantages:- (i) Centre winze or raise is blocked by broken ore. (ii) ventilation of working place is difficult. (iii) Shovelling is required from bench to bench. (iv) Blasting is not efficient.

Breast Stoping:-

Conditions:- (i) Thin ore body is required. Thickness less than 4.5m (ii) inclination betn 10° to 30°. (iii) Low grade ore body. (iv) Strong hanging wall & foot wall. It should stand unsupported.

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→ Stoping / Stope working :- → In this method ore is broken by flat or Inclined holes drilled in vertical or nearly vertical face.

→ It is advanced in a nearly horizontal dirn and the work is done from the boundary side towards the ore body.

→ Breast holes are made in the ore block of length 1m to 1.5m for a distance of 6m. Wedge cut or Pyramid cut holes are used.

→ The holes are charged and blasted. The blasted ore is manually removed in the chute. This is loaded in tubs or conveyor for further transport.

→ Thus part by part ore block is worked from upper level to lower level. Thus a sufficient space of 4m to 6m is formed.

→ Breast stoping is a low cost, simple method preffered for low grade ore deposits. The ore and wall rocks should therefore be strong.

→ Deposits up to 3m thickness are normally mined in one face or lift. For width greater than 3m, breast stoping can still be adopted by taking the top 2m by breasting and rest by underhand stoping.

→ Ore chutes are provided at 4-6m intervals.

Advantages :- (i) The broken ore is regularly removed.
(ii) Sorting of ore is possible.
(iii) Face mechanisation is possible.
(iv) Method is simple and cost is less.

Disadvantages :- (i) selective mining is not possible.
(ii) Not suitable for thick deposits i.e. more than 6m.

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Cut & fill Mining :-

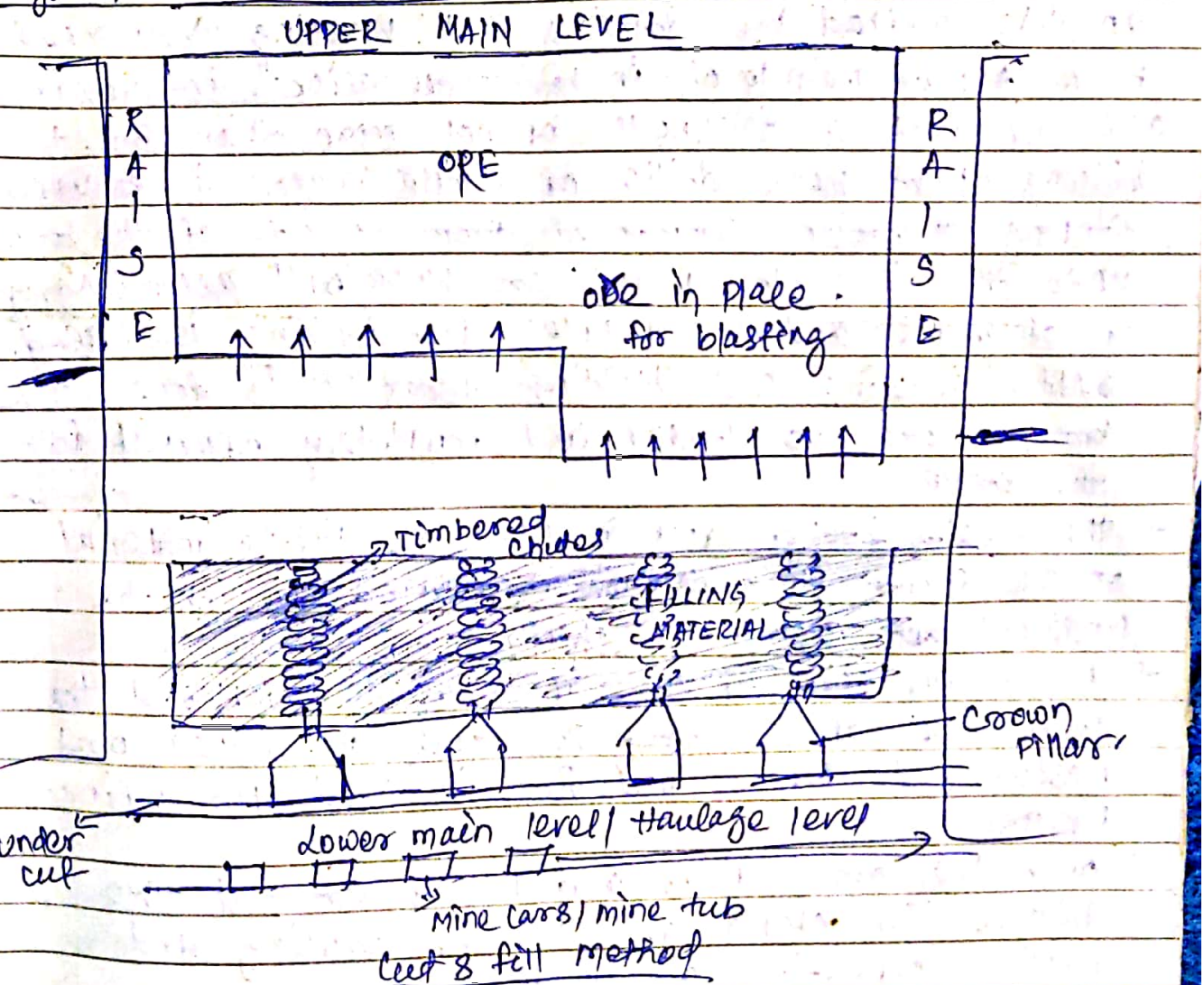
Applicability :- → It is applicable in thick and extra thick ore body.

→ This method is applicable with steeply dipping deposits.

→ It is most suitable in which ore body having irregular outlines.

→ The ore should be free flowing in nature.

Figure :-



Cut & fill method

Development :- → The ore body is developed through a shaft or incline. The cross cuts are driven as regular intervals to search the ore body.

→ When cross cut touches the ore body the levels are driven at regular intervals

~~and connected~~

→ Raises and winzes are driven to connect from a level to another level. The lower level is used for loading level or haulage level.

→ then undercut is driven usually 5–10m above the haulage drift.

Stope working :- → stoping operation is started right from the lower level after forming the crown pillars for protection of lower level.

→ In this method by drilling and blasting commenced from lower main level in horizontal slices. in upward

→ A slice has a thickness of not more than 3m. for drilling light rock drills of simple wagon is used

→ stoping operation commenced from one side of the boun up to the ½ width of the ore block and according to no. of rows and no. of holes for drilling is placed.

→ After drilling and blasting operation is done, the broken ore is loaded and completely removed from the stope.

→ The waste broken rock is used as filling material on the crown pillar as the ore moved through the undercut to the loading drift.

→ After one side of the operation is completed the other side of the ore block is drilled and blasted and waste material is used for filling purpose.

→ over the crown pillar and filling material the drillers can stand and further drilling and blasting operation can be done.

→ The filling material is mostly waste rock and in some cases hydraulic filling method is also being implemented.

→ As the stope proceeds upwards timbering and filling proceed on cyclic basis. from lower ma level up to upper main level.

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1) Sublevel stoping :- 1) Applicability Condn :-

→ This method is suitable for thick and extra thick ore bodies.
→ The footwall and hanging wall should be stable in nature.
→ The ore body should be strong enough to stand on its own weight.
→ The ore body should be steeply inclined and angle of inclination should vary from 40° up to 85°.

2) Development :- Same as cut and fill stoping method and add the following point.

→ A draw point system consisting of finger raises provided from crown pillars to the undercut for smooth transportation of booken ore.
→ The ore block is divided into two parts by driving a centre raise directly into the ore body where the ore body is extra wide in nature.

→ Stope Preparation :- same as cut & fill stoping method.

→ Stope working :-

→ The clearance betn the crown pillars and the ore body will act as sublevel-1.
→ After sublevel-1 is properly formed or driven then work is done for preparation of the slice-1.
→ The slice-1 can be formed by widening up the mouth side of the sublevel from stoped side up to a distance of 4 to 8m length at one time.
→ This is done by drilling breast hole of wedge or pyramid cut of holes are used for drilling and blasting.
→ The blasted ores are manually or mechanically shovelled to the vertical hole of crown pillar, through undercut and is loaded in the lower level.

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→ In this way the mouth of sublevel is further widened and slice-1 is formed. The gap formed over the slice-1 is called as sublevel-2.
→ When widening operation of sublevel-2 is in progress, also the extraction of slice-1 begins, from one side.
→ After sublevel-2 is completely formed, working starts for the formation of sublevel-3.
→ Extraction of slice-1 and sublevel-2 formation is done simultenously.
→ So each slice can be made of thickness depends up on the total thickness of the ore body and total no. of slices to be made. So thickness of each slice can be made betn 4 to 5m while the width of the sublevel ranges betn 2 to 3m.
→ The formation of 2nd slice of the ore betn the 2nd and 3rd sublevel will be formed, by same drilling and blasting and widening of the mouth of the sublevel-3.
→ During formation of the sublevel-3 also extraction of slice-2 is done simultenously.
→ After the extraction of slice-2 and sublevel-3 is formed, then working starts for the formation of sublevel-4 and slice-3.
→ The working of 4th sublevel and 3rd slice will be lagging behind the working of 3rd sublevel expansion and 2nd slice working or extraction.
→ The blasted ore of all slices and sublevels are shovelled in to the crown pillars and to the lower main level.
→ All the sublevels and slices will be worked one by one from lower main level up to upper main level.

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→ when the stope working is complete the crown Pillers will be partly worked below the first sublevel before removing the loading chute.

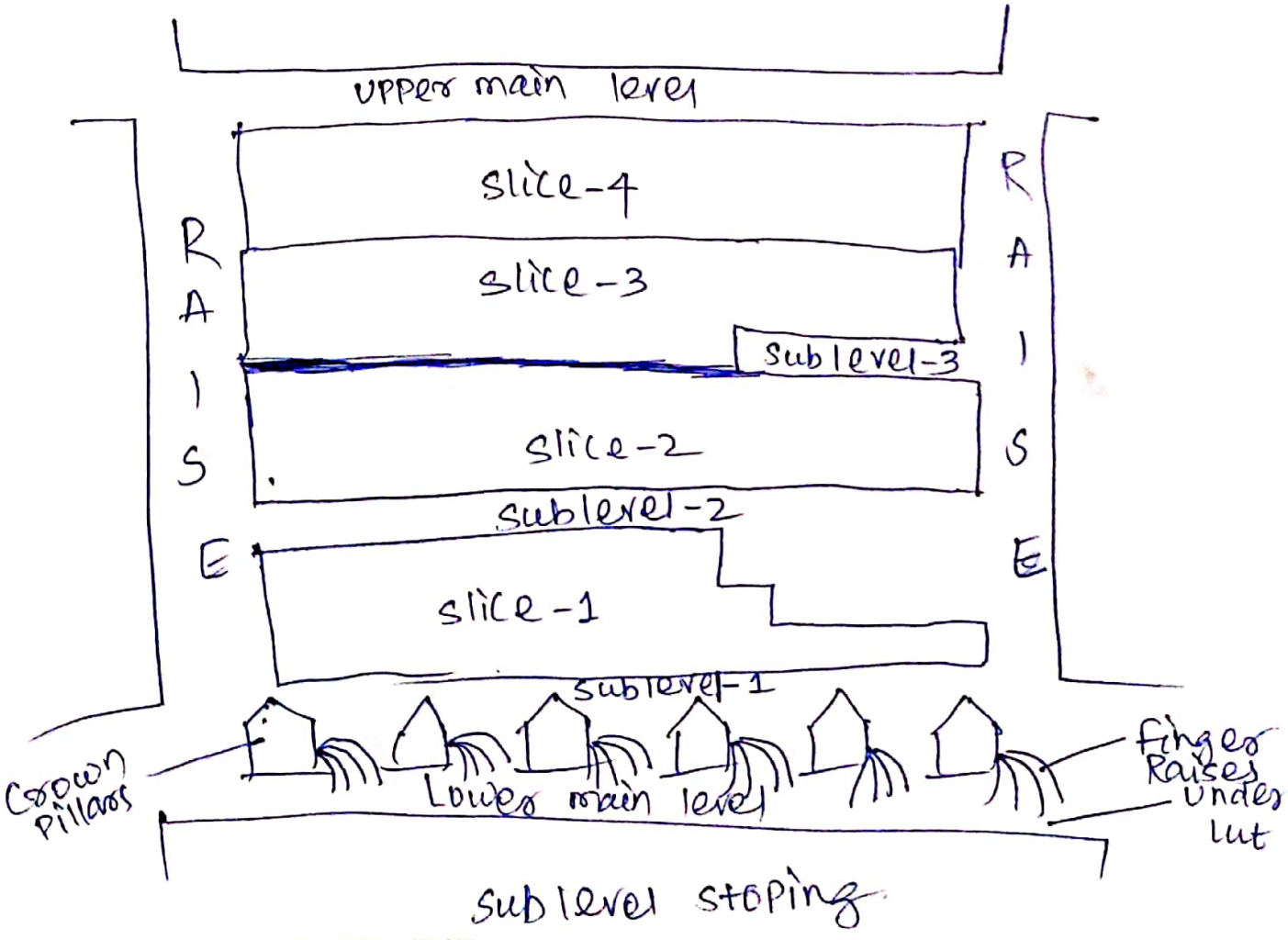
→ The drilling is here often performed with light air leg rock drills. or medium sized jumbo drills.

Advantages :

→ workers standing on solid ore drill the breast holes.
→ continous availability of ore as there is no requirement for filling.
→ There is shoot distance of shovelling and transport.
→ High Production rate can be achieved.
→ Good ventilation is maintained through sublevels

Dis Advantages :

→ It takes very long time for preperation of stope.
→ It is difficult for drillers to drill the holes at the edge of the sublevels with assistance from ladders.



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Shrinkage stoping :-

Applicability Condn :- → This method is used for thin ore body or thick ore body. and also applicable for extra thick ore body.

→ It is suitable for strong ore body that can stand the pressure and its own weight.

→ The inclination required is more than 40° upto 85°.

→ The grade of ore body ~~during the final withdrawal~~ required as high as there is possibility of dilution of ore body during final withdrawal of broken ore ~~from the stope~~.

Introduction :- The shrinkage is an overhand stope method. The broken ore is used as support to ore body. The broken ore occupies 30% to 40% space thus 30% to 40% ore withdrawn during stope working. Rest of broken left in stope. This gives temporary support to walls.

Stope working :-

→ A hz. drive of size 1.5 - 2m ht. and width equal to the thickness of ore body is driven in the ore block. The hz. drive is driven at height of 2-4m from roof of lower level. Breast holes of wedge pattern are used for this drivage.

→ 1.0m dia. holes are made from hz. drive to connect with lower level. These vertical connections are made at regular intervals of 2-4 m. Thus crown pillars are formed from lower level and horizontal drive.

→ The length of face formed is 5 to 10m in longitudinal dirn. The vertical upward holes are made in a row in the roof of horizontal drive to form overhand face.

→ The no. of rows of holes are 2 to 4 depending up on the width of ore body. The holes are charged and blasted over crown pillar.

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→ the ore face so formed is dressed, 30-40% of broken ore is removed through the chute in the lower level for transport.
→ Thick wooden planks or steel sheets are bolted to these pillars on open side to form compartment. and these are sufficiently heightened.
→ The broken ore with in the compartment is spread over and again the rows of vertical upward holes are made in 2-4 rows in first face. These holes are made standing on the broken ore with in compartment.
→ These holes are charged & blasted. 30 to 40% of freshly broken ore is loaded through chute in lower level for transport. The face is well dressed. and the compartment is further extended.
→ In this way from lower main level up to upper main level the extraction can be done and it ends when the upper main level reaches, where stope working is completed of ore block.

Adv.:- (1) The broken ore with in the compartment form a platform for workers to work the face.
→ There is less timber support requirement.
→ Face can be well dressed and broken ore is cleared of the face.
→ It is a cheap method of working.
→ Faces can be additionally supported.

Its advantages:
→ There is possibility of dilution of wall rock with ore.
→ Sorting of ore in the stope is not possible.
→ Selective mining is not possible.
→ As large block of ore is formed, but secondary blasting is not possible in this case.
→ Movement of drillers and workers over broken ore is difficult.

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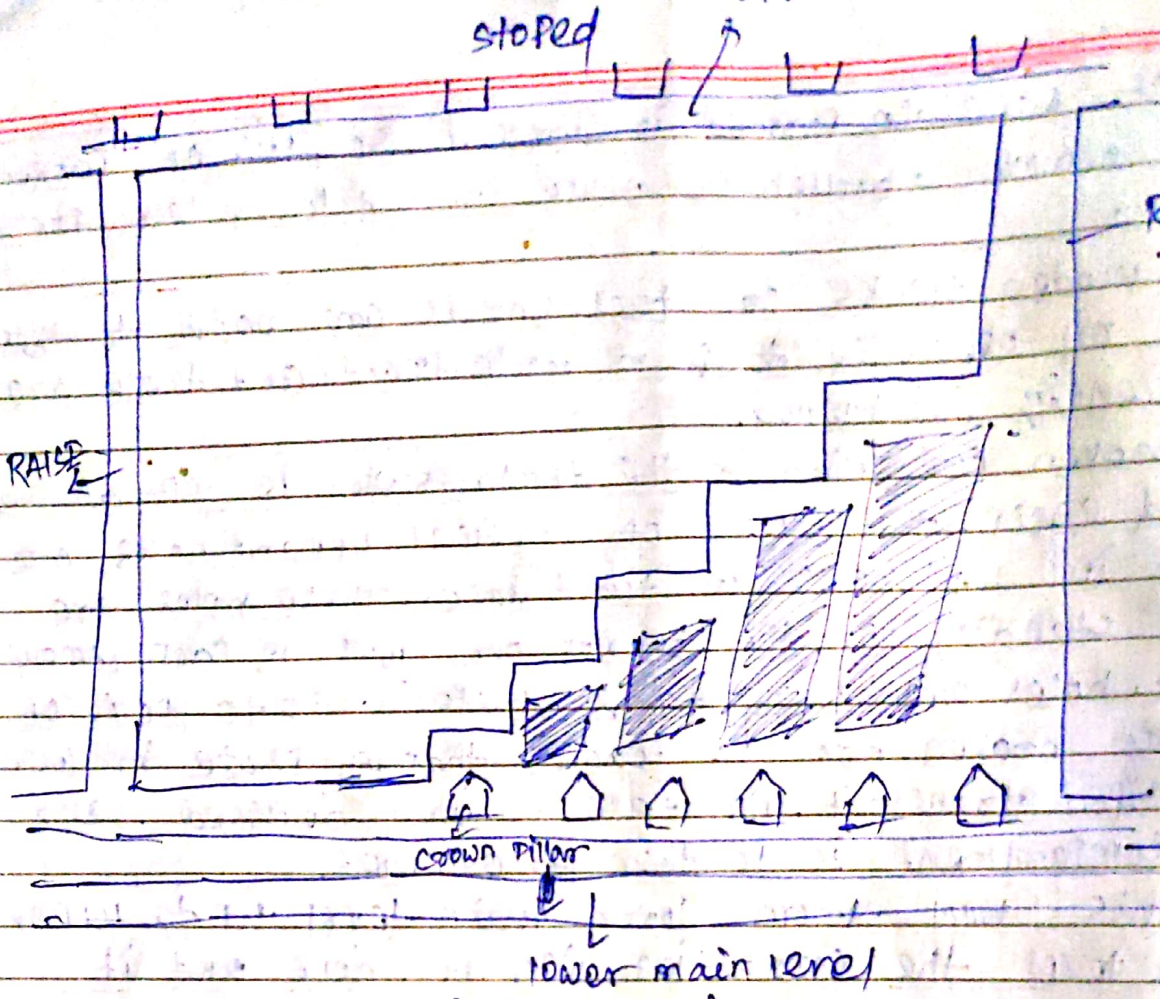

Shrinkage stoping

Top slicing :- Applicability Cond :-

→ This method is used when the ore body is thi and extra thick ore body.

→ when the ore body is weak and not able to stand starta Pressure for long time.

→ The ore body in this method is high goode and regular ore body.

→ Ample supply of low cost timber (Green wood) is requirred.

Development :- Same **Stope Preparation :-** Same

stope working :- → In Place of working. Complete thickness of ore body floor up to roof, only Part of thickness of ore body is worked. only 2-3 m thickness of ore body is worked along the roof in ~~this~~ this

→ A horizontal drive of size 2-3 m ht up to the ore is driven. Breast holes of wedge or Pyramid Patter are used for drivage of horizontal drive.

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→ The blasted ore is shovelled to the lower main level for transportation.
→ As horizontal drive advances it is systematically supported by green wood. The green props are set in two rows. and they are set in 1m interval in a row.
→ After blasted ore is removed from the face, it is regularly supported by green wood.
→ The floor of the cross drive covered by grids. and the grid is formed out of ~~2.5 cm to 5.0 cm thick~~ about 12.5 cm dia. thick wooden planks suitably tied together by wire. This is called as timber matt.
→ After formation of timber mat 50% of green woods are withdrawn i.e. alternate props are withdrawn.
→ If the roof of the cross drive does not cave in some of the green wood is tied with explosive catridge and the blasted. The roof of the cross drive will cave in on the timber mat on the top of 2nd slice. on the floor of 1st slice.
→ similar cross drive is worked towards footwall side in the similar way and it is also caved after working is complete on formation of timber mat.
→ Thus the 1st cross drive is complete up to hanging wall and foot wall and similarly 2nd cross drive is worked from the horizontal drive.
→ The 2nd slice working is started below the caving of 1st slice. 30-40 cm thick ore cover is left between the caving and working of 2nd slice.
→ The 2nd slice is developed and the slice is extracted similarly as 1st slice, but in this case of caving of cross drive is made directly on top of 3rd slice without formation of any timber mat.
→ similarly the 3rd slice and other slices are worked till the complete ore body thickness is worked.

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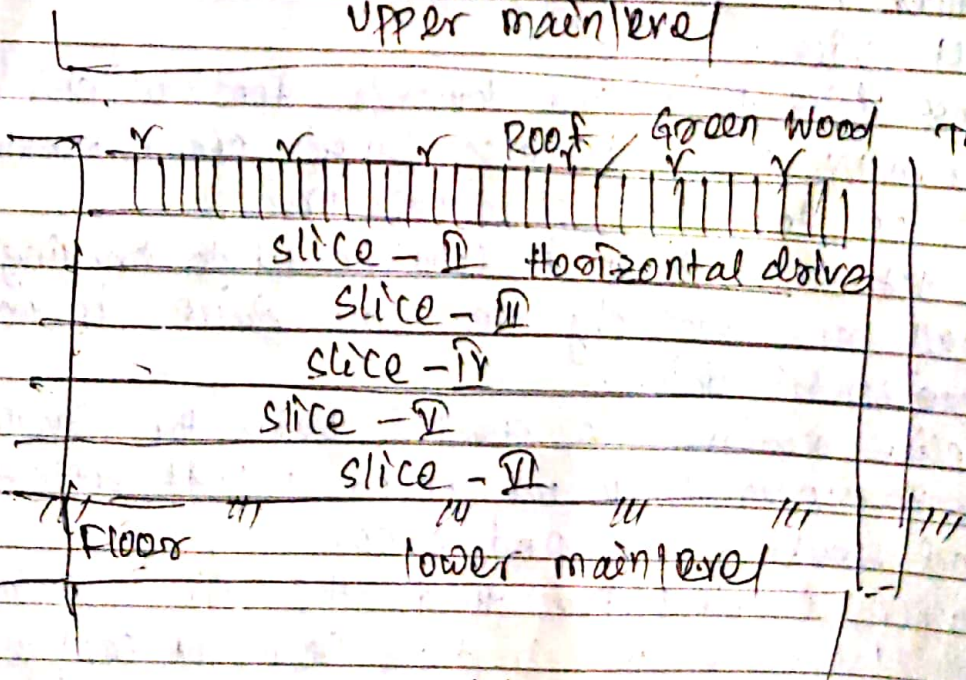
Advantages :- → It is a safe method to use where overhand stoping can't be employed.
→ Drilling is easy as breast holes are drilled.
→ Sorting of ore is possible in stope.
→ After initial development is completed the method can be reasonably cheap, provided the labour & timber are cheap.

Disadvantages :- → loss of timber is high 50% or more.
→ Dilution of ore may be possible.
→ Period of development Prior to Production is fairly long.
→ There is possibility of fire hazard.
→ There is a high chances of surface subsidence.



Topslicing method.

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sublevel
[redacted] caving :- Applicability Condn :-
→ This method is used for thick and extra thick ore body. → It is suitable for weak and moderately soft ore body.
→ The hanging wall & foot wall are weak.
→ The ore body is moderately high grade.
→ There should be ample supply of green wood.
Development :- Same as top slicing method.
Stope working :- → The raise is driven from lower drift up to the top ore body. The size of the raise is 2-4m x 1-3 m. One compartment of raise is used as ore pass and other compartment is used for ladder, ventilation pipe and power cable for light.
→ When the raise is driven, the no. of slices to be formed in the ore block is always even.
→ The thickness of top most slice is 3-4m and also for all other odd slices. and all other even slices ht. worked is 4-8m. and the total no. of slices formed in this method is always even.
→ In this method only even no. of slices are worked. and below the odd no. of slice. The slices are worked in descending order.
→ A sublevel is driven in the 2nd slice [redacted] below the first slice, which acts as a Protective cover.
→ The sublevel is supported by two rows of green wood at regular intervals. When the sublevel development is complete the full height of 2nd slice is worked
→ When the Coocs cut drive is complete by breast holes drilling & blasting the green wood support of the drive is withdrawn and allowed the 1st slice to cave in. In this way the complete 2nd slice is [redacted] worked up to the raise. The 1st slice is completely caved on the top of 3rd slice.
→ When the working of 2nd slice is complete. the 4th slice is worked, the 3rd slice work as Protective covering.

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→ The 2nd sublevel is similarly driven and supported. The cross drive is similarly driven by breast holes and regularly supported by green woods in rows.

→ When the cross ~~drive~~ drive is driven 50% of alternate supports of cross drive are withdrawn and the 3rd slice is allowed to cave in.

→ In this way the 3rd sublevel drive can be driven in the 6th slice and the 5th slice will cave on the top of 7th slice.

→ Thus every even slice is completely worked by sublevel and cross drives. Every odd slice is allowed to cave in.

Advantages :- → There is no dilution of ore during working of even slices.

→ Grade of ore is not much affected.

→ Less timber work is required in this method

→ Impact of caving is less due to solid cover by lower slice.

→ Workers stand on solid ore.

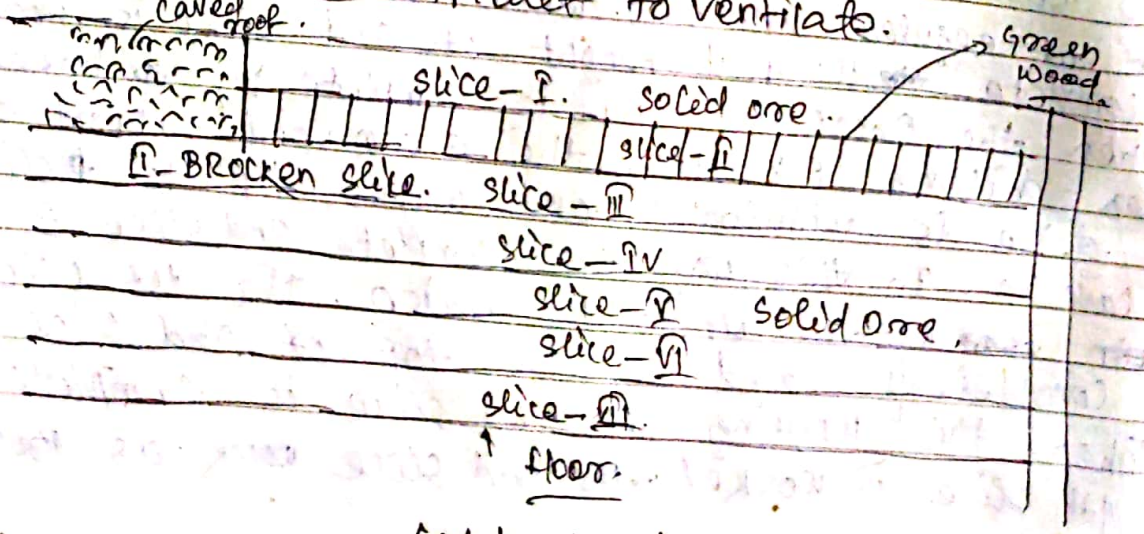
Disadvantages :- → Recovery is less as compared to top slicing method

→ Sorting of ore is not possible.

→ Clearing of ore is difficult.

→ Usually more dilution of ore in this method than top slicing.

→ The stopes are difficult to ventilate.



Sub level caving

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Block Caving :- Applicability Condn :-

→ This method is used for thick and extra thick ore body.
→ It can be used for wide and extra wide ore body.
→ It is used for weak ore bodies.
→ It is suitable for weak walls. where both hanging wall and foot wall are not able to stand starta pressure.
→ It is suitable for high grade ore bodies.

~~Development~~ →

Development :- → There are drifts connecting the levels and these drifts divide the complete ore body in to sizes of 15 to 25m block
→ The end of drift centre occupies the centre of ore block. Two inclined raises are driven at an angle more than 40°.
→ It is divided in to two compartments. one compartment is used as ore pass. These inclined raises are connected vertically to the bottom of ore body.
→ Branch raises are driven vertically upward from 2 incline raises such that the branch raises will meet the bottom of the ore body at regular intervals of 2m.
→ The vertical branch raises meet the centre of width of ore body.
→ 3 branch raises set is used in place of single branch raise in case of wide ore body.
→ The throats of all inclined raise and branch raises are meet at the bottom of ore body. A horizontal drivage is made along the floor of the ore body such that this drivage connects the throats of all branch raises which are at the centre of ore body width.

Stope working :- → 4-6 ring holes are made in the roof the undercut in such a way that their centre is the centre of throats of branch raises of the group. The length of hole is 2m.
→ These holes are charged with explosives and blasted. The blasted ore fall in the throats. The blasted ore will then run in the ore pass of inclined raises.

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→ The broken ore is withdrawn by chute and loaded in the tubs. and then ore is transported to shaft. → As Broken ore is withdrawn the gap is formed betn the broken ore and badly disturbed ore body above. The disturbed ore body caves on the throat.

→ As loading continues the broken ore follows. with rock mixed ore. when percentage of rock mixed ore is more, the chute of branch raised is closed.

→ Now the 2nd branch raise is provided with chute connected to ore pass of incline raise. The ladder is provided to the third branch raise.

→ The 2nd undercut above 2nd branch raise is similarly blasted and blasted ore is loaded in drift as described till the flow of broken ore contains more rock. The chute of 2nd branch raise is closed, the extraction is complete. In this way all branch raises undercuts are worked and complete ore block has caved and complete ore of the block is withdrawn from chutes in the drift.

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Square set stoping :- Applicability Cond^{n} :-

→ This method is suitable for thick and extra thick ore body.
→ The inclination of ore body is suitable up to 70° to 85°
→ The ore body is strong and can stand on its own weight.
→ The ore body should be costly mineral.
→ There should be continous supply of timber of low cost.
→ The mine should be close to forest, so that cost of support will be low.

Development :- Same as sub level stoping.

Stope working :- → In this method working the overhand benches are formed.

→ Standing on the floor of lower level, these holes are made in a single row on either side of the centre raise. and the no. of holes in a row will be 3 to 6 depending up on the width of ore body.
→ The length of the hole will be equal to the inverted height of the bench to be formed.
→ These holes are charged and blasted. The blasted ore will fall in lower level. The first inverted bench will be formed on the either side of the centre raise.
→ The bench is dressed and vertical upward holes are again made on either side of centre raise in the first inverted bench to form and inverted bench. and these holes are charged & blasted. Then sufficient space will be formed for erection of square set.
→ The blasted ore is loaded in lower level. The sill is set on the floor of lower level extending from hanging wall to foot wall. The square sets are formed in the area where inverted benches are formed.
→ The top of 1st square set is kep covered to protect from any fall of ore piece to lower level.
→ Another square set is covered from all sides. and it is provided to use as ladder way, carrying Power Cables, Compressor pipe, The top of square set is covered by thick wooden planks and Platform is formed.

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→ At one time only 1 to 4 benches are worked on one side of the centre raise, starting from lower level.

→ A single row of holes are made in the inverted side of 2nd bench and these holes are charged & blasted. the blasted ore is loaded in the lower level.
→ No.3 bench is formed the 2nd & 1st benches are extended. and the square set is extended to reach the No.3 bench, No.2 bench and No.1 bench.
→ The blasted ore of 2nd and higher benches falls on top of platform formed on the top square set. The blasted ore on the platform removed to lower level benches.
→ In next operation higher benches, 4 to 8 are worked similarly square sets are also advanced. when the square sets are advanced the ore passes and ladder ways are also advanced.
→ when the square set is kept so advanced, when the planks are kept on the top of set, the face can be easily reached and can be worked.
→ Thus in this way complete ore block is worked on either side of centre raise and walls are regularly supported by square set.

Advantages :
→ Sorting of ore is store is possible.
→ ventilation at the face is very good.
→ very high efficiency of blasting.
→ The faces can be well dressed.
→ walls are regularly supported.

Dis-advantages :
→ It is not suitable for thin ore body of low grade.
→ cost of timbering is high.
→ The platforms are set and dismantle every time.
→ Huge amount of timber is required for support.

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Rock Burst :→ Rock burst is a sudden violent failure of rock in and around the mine opening. It generally occurs in strong brittle rocks which contains few Pre-existing fractures.

→ In this case rocks are weak in tension and strong in compression. hence large quantity of potential energy is stored in the rock under high compressive stress.

→ The potential energy by parts is stored as strain energy in rock and reminder is released non violently, through crushing of rock is known as Rock burst.

→ Rock burst occur frequently if the rate at which energy is released is greater than the rate at which energy can be dissipated, as a result fracture occurs. In mining field rock burst occurs frequently.

→ In rock burst the strain energy is released from the stressed rock mass violently with a magnitude of seismic events ranging from 1 to more than 5 in the Richter scale.

Rock burst depends up on the following factors :-

→ Presence of fault, dykes and geological disturbances increases the occurance of rock bursts.

→ when the rate of face advance is lower, then chances of rock burst is more.

→ where the height of extraction and depth of working is more then there would be occurance of rock burst is more.

→ Decrease in abutement size will increase the occurance of rock burst.

→ Increase in the span of the face, will increase chances of rock burst.

Control measures of Rock burst :-

→ By reducing the energy release slowly by developing yielding pillar which yield gradually instead of accumulating high stresses over the pillars.

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→ Leaving no pillars in the goaf, since these pillars will be under very high stress as time passes on. Planning of the extraction process and layout should be such that no development is carried out in abutement zone. line of pillars in the panel must be straight.
→ Avoid dykes, faults and other geologically disturbed zone which are highly stressed. working should be started from nearby spot of the disturbed area and shall be moved away from them.
→ By fracturing the rock ahead of the face blasting will reduce the level of stresses in the rock.
→ By back filling the extracted out area with sand and any other waste material and providing very high support density in the face.
→ By faster rate of face advance.
→ By having limited no. of working faces and mining the faces towards each other must be avoided.
→ By partial extraction of the developed pillars or by leaving pillars spaced regularly along the whole length of Longwall panel.
→ By pre-destressing with blasting.
→ By providing adequate supporting in underground mine working.
→ By introducing special shotfiring techniques.
→ By high pressure water injection in the coal which will cause variation of existing stress concentration & also changes the mechanical properties of coal.

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