



EXAMINATION PAPER

SUBJECT: CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN STRATA CONTROL – METALLIFEROUS SUBJECT CODE: COMCSC EXAMINATION DATE: TIME: 14:30 – 17:30	EXAMINER: Y. JOOSTE MODERATOR: D.A. ARNOLD. TOTAL MARKS: [100] PASS MARK: (60%)
--	--

NUMBER OF PAGES:

THIS IS NOT AN OPENBOOK EXAMINATION – ONLY REFERENCES PROVIDED ARE ALLOWED

SPECIAL REQUIREMENTS:

1. Answer **all questions**. Answer the questions **legibly** in English.
2. Write your **ID Number** on the outside cover of each book used and on any graph paper or other loose sheets handed in.

NB: Your name **must not** appear on any answer book or loose sheets.

3. Show all calculations **and check calculations on which the answers are based.**
4. Hand-held electronic calculators may be used for calculations. Reference notes may not be programmed into calculators.
5. Write **legibly** in ink on the **right hand page** only – **left hand pages will not be marked.**
6. Illustrate your answers by means of sketches or diagrams wherever possible.
7. **Final answers** must be given to an accuracy which is typical of practical conditions, However be careful not to use too few decimal places during your calculations, as rounding errors may result in incorrect answers

NB Ensure that the correct unit of measure (SI unit) are recorded as marks will be deducted from answers if the incorrect unit is used. (even if the calculated value is correct).

8. In answering the questions, full advantage should be taken of your practical experience as well as data given.
9. Please note that you are not allowed to contact your examiner or moderator regarding this examination.
10. Cell phones are **NOT** allowed in the examination room.

QUESTION 1 – DEFINITIONS

Define the following terms and where applicable give the symbol and units used:

1.1 Homogeneity

Rock mass having the same mechanical properties at all points, consists of the same material throughout.

1.2 Poisson ratio

- Is the ratio of lateral strain to the axial strain in a body under the influence of stress –

$$\nu = -\frac{\epsilon_L}{\epsilon_a} \quad (\text{no units as it is a ratio})$$

1.3 Shear modulus/modulus of rigidity

- A combination of young's modulus and poisons ratio into a single modulus
- Also known as the shear stiffness is the shear stress divided by the shear strain.

$$G = E / 2(1 + \nu)$$

1.4 Bulk Modulus

- Is a measure of volumetric stiffness under normal loading conditions and is given by:

$$k = E / 3(1 - 2\nu)$$

1.5 Potential Energy

- Potential energy of a body is its ability to do work because of its position or state

$$Pe = mgh$$

- This is the work a body is capable of doing when moving from one position to another relative to the gravitational effect of the earth. Unit of energy is Joules,J.

1.6 Kinetic energy

- Kinetic energy, which is a measure of the ability of a body to do work because of its motion.

$$Ke = 1/2mv^2$$

1.7 Slabbing

- Breaking off of thin slabs from the rock face as a result of high stresses in the rock around the excavation.

1.8 Yield

- When there is departure from the elastic behaviour in the material and some permanent deformation occurs.

1.9 Mass

- Is the quantity of matter in a body
- $m(kg) = volume(m^3) \times density(kg / m^3)$
- Density(ρ)

1.10 Weight

- Weight is a force
- Weight (force) = mass x gravity
- What is weight of a block with mass 1000kg = $m \times g = 1000 \times 9.81 = 9.81kN$

[20]

QUESTION 2 – GENERAL

Indicate if the following statements are, True or False

- 2.1 Boreholes drilled in high stress intact rock exhibit immediate spalling or dog-eared. **TRUE**
- 2.2 Diurnal distributions of seismic data show a pronounced peak in seismicity just before the blast occurs. **FALSE**
- 2.3 Since closure rates in shallow environments are low and horizontal clamping are absent, stiff local support is required to control the hangingwall. **TRUE**
- 2.4 Sequential grid mining involves a grid of pre-development with breast mining up to dip pillars left intact. **TRUE**
- 2.5 Wherever possible, tunnels should pass closely above or below pillars and abutments to ensure minimal damage as a result of high stresses. **FALSE**
- 2.6 Cave mining is a term used to describe the practise of supporting only the immediate working area of advancing panels and allowing the unsupported back area to collapse in a controlled fashion. **TRUE**
- 2.7 Stopping is considered steep when the dip of the strata exceeds 35 degrees. **TRUE**
- 2.8 Depth of fracturing ahead of the stope face is directly related to the ERR. **TRUE**
- 2.9 Ride is the differential oblique movement between the hangingwall and footwall and is affected by factors such as reef dip. **TRUE**
- 2.10 Overstopping is an effective method of protecting off reef excavations from the effects of mining induced stress changes. **TRUE**

[10]

QUESTION 3 – SEISMICITY

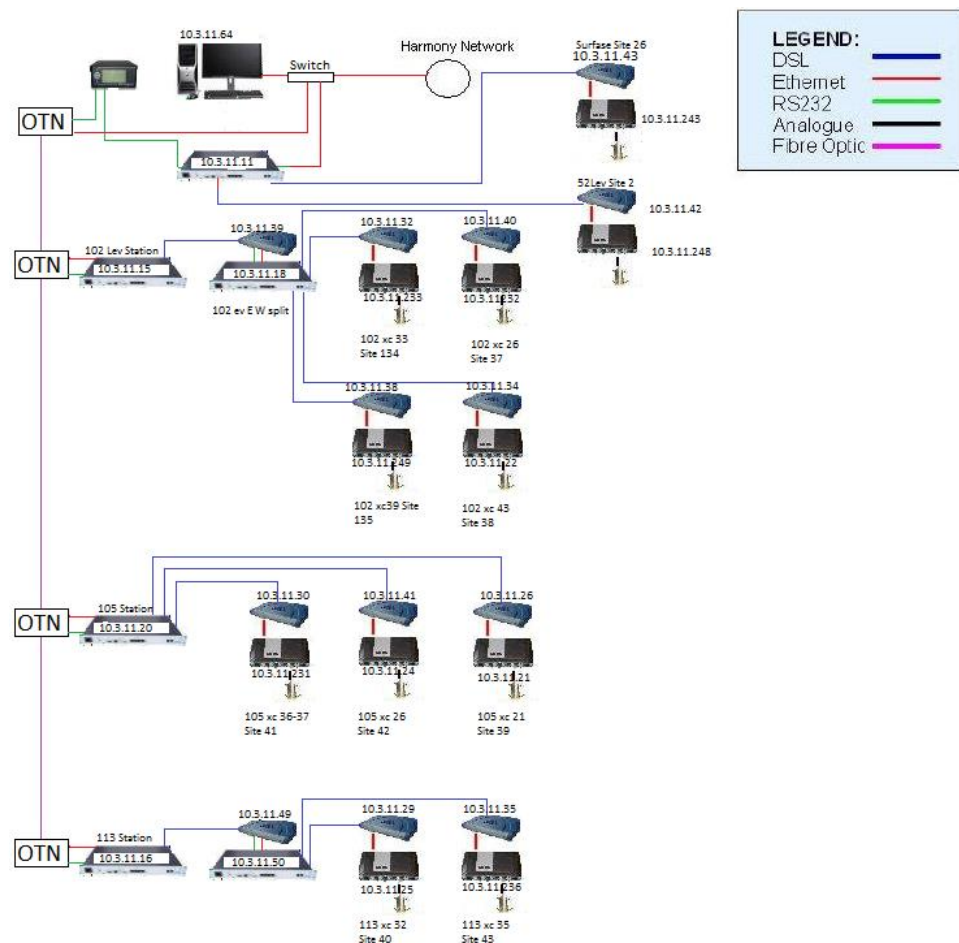
3.1 Define a seismic event. (2)

Sudden release of in-elastic energy in the form of seismic waves.

3.2 Define a rock burst. (2)

Seismic event that causes damage to underground workings or infrastructure
(Not what is a faceburst looked for “damage” not violent)

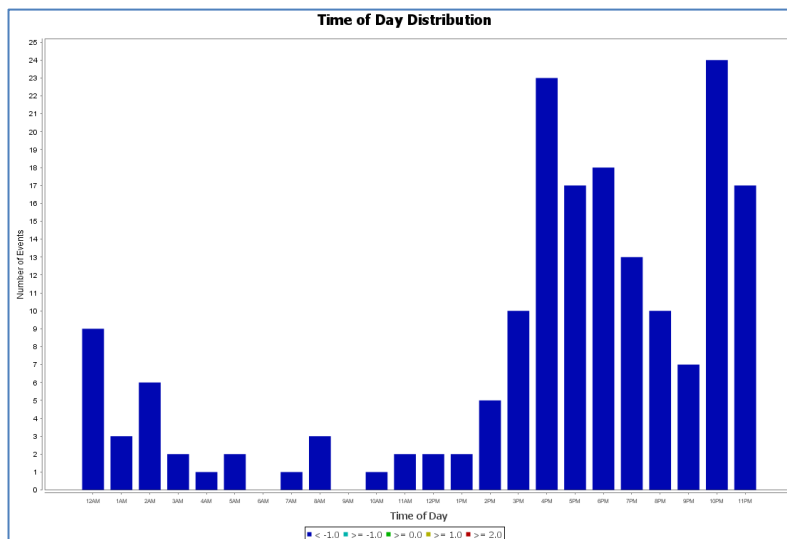
3.3 Draw a basic seismic system layout. Annotate component of network clearly. (5)



Did not expect the amount of detail. Geophone, GS connected with the central site on surface and then some sort of why of communication cable/fibre.

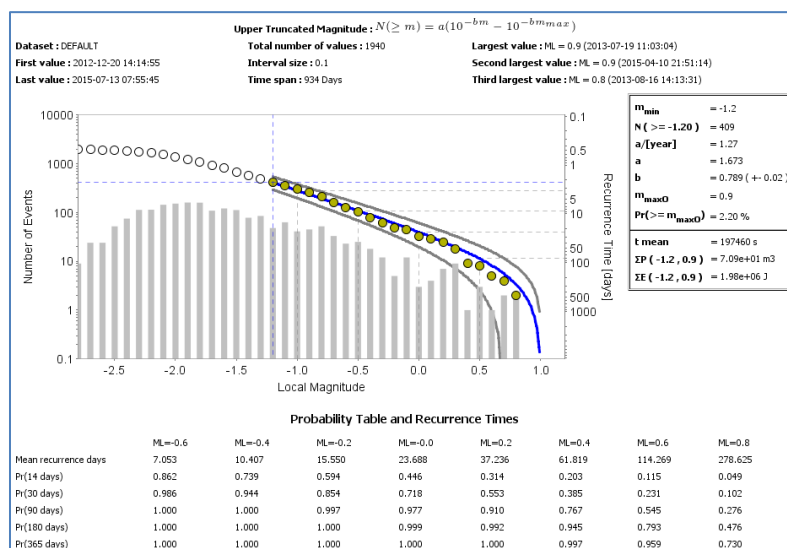
3.4 The following two plots were obtained after while analysing the seismic data recorded by the seismic system:

3.4.1 Plot A - What is shown by this plot and how can it be used? (2)



Histogram of the time of day of the seismic events that occur. Management can determine from this when blasting is occurring on their shaft and the re-entry time period after blasting.

3.4.2 Plot B – What is shown by this plot and how can it be used? (2)



Histogram showing the number of events per magnitude range. This plot is used to determine the seismic hazard that is associated with the specific area.

3.5 Why will a seismic network be installed on your mine? (2)

- To determine if any seismic events are occurring
- To determine the possible location and sources of seismicity
- To send rescue operations to the correct location where event occurred
- To determine the seismic hazard of working areas

[15]

QUESTION 4 - SUPPORT

4.1 Draw a load deformation graph showing/depicting the following

- Yield load
- Yieldability
- Brittle failure
- Initial stiffness
- Energy absorption
- Pretension

P209 Handbook on Rock engineering practice. (8)

4.2. Sketch the following mesh and lace patterns:

4.2.1 Basic 1m square lace and tendon pattern

4.2.2. Double 2 x 1.6m diamond pattern. (4)

P212 Handbook on Rock engineering practice.

4.3 General rules of thumb are frequently used in the design of support systems within the mining industry.

4.3.1 What is the rule of thumb length of tendons if the width of the tunnel is 2m?

1m tendons $\frac{1}{2} \times \text{span or height of excavation}$

4.3.2 What will the rule of thumb spacing be of the tendons mentioned in Q4.3.1 above?

0.5m $\frac{1}{2}$ length of tendon

(2)

4.4 Sketch the typical stope fracturing pattern at a depth of 2000m below surface. (6)

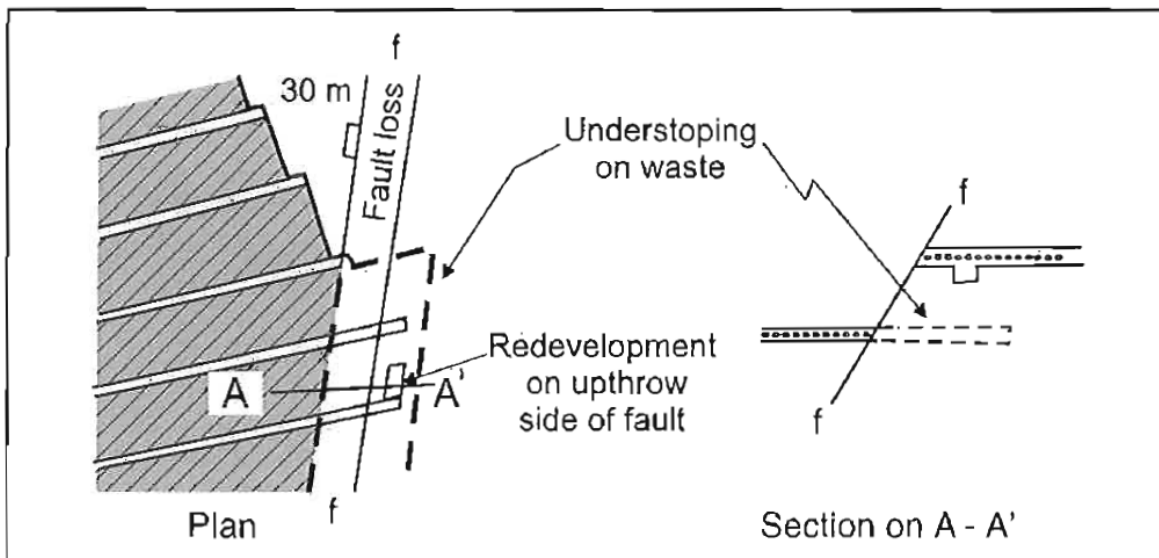
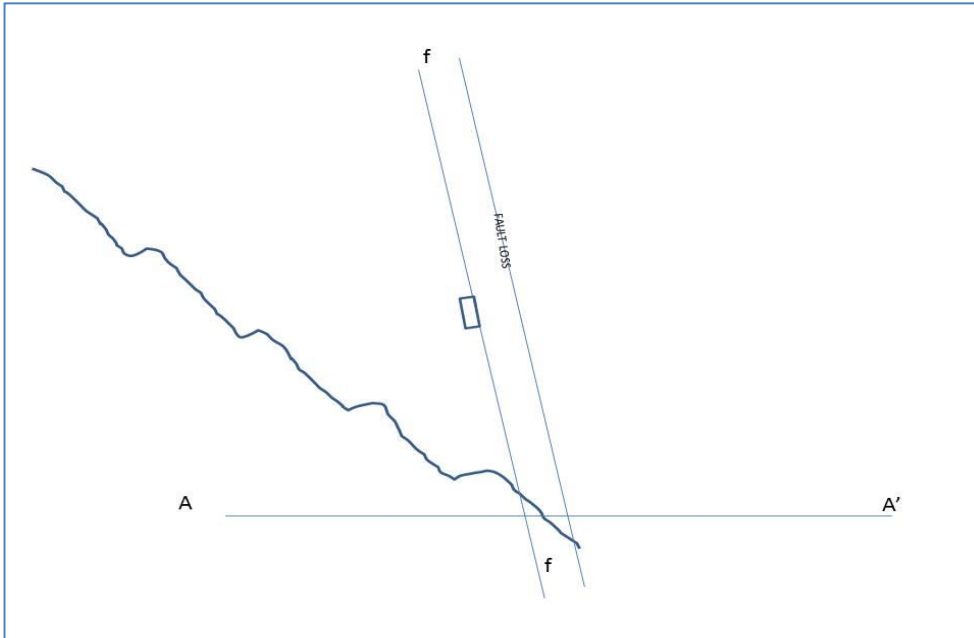
P121 Handbook on Rock engineering practice.

[20]

QUESTION 5 – MINING

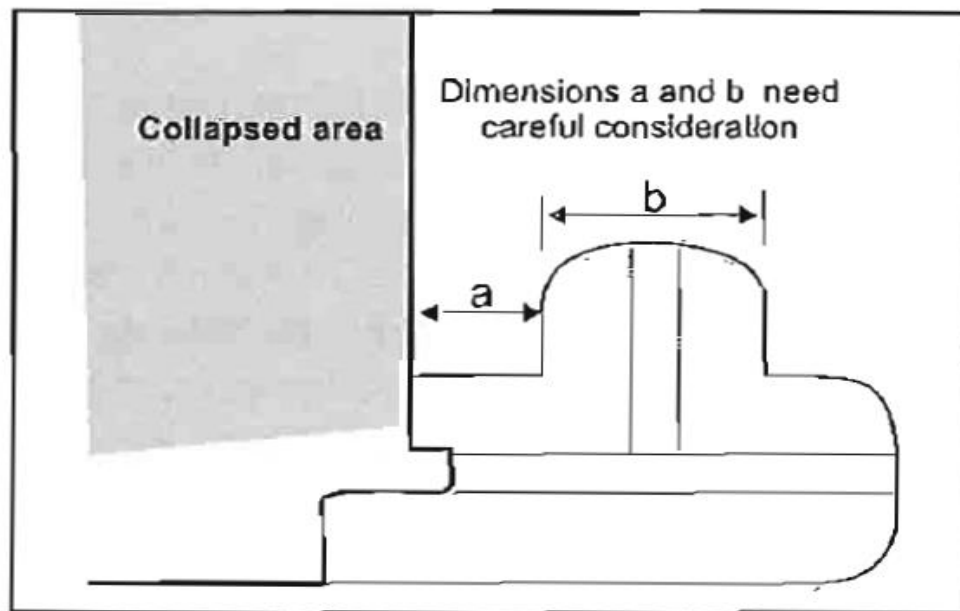
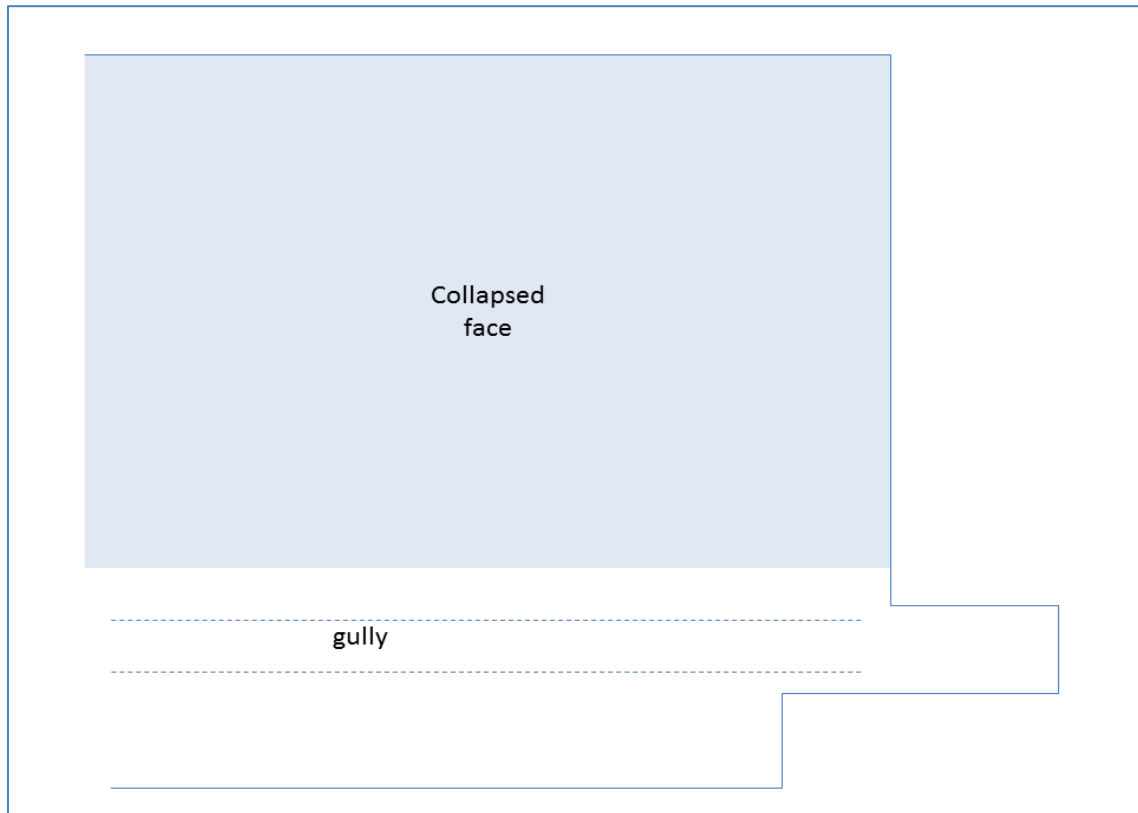
5.1 Redraw the following sketches and indicate how you would:

5.1.1 Negotiate the geological structure ahead of the stope face on plan and section:
(3)



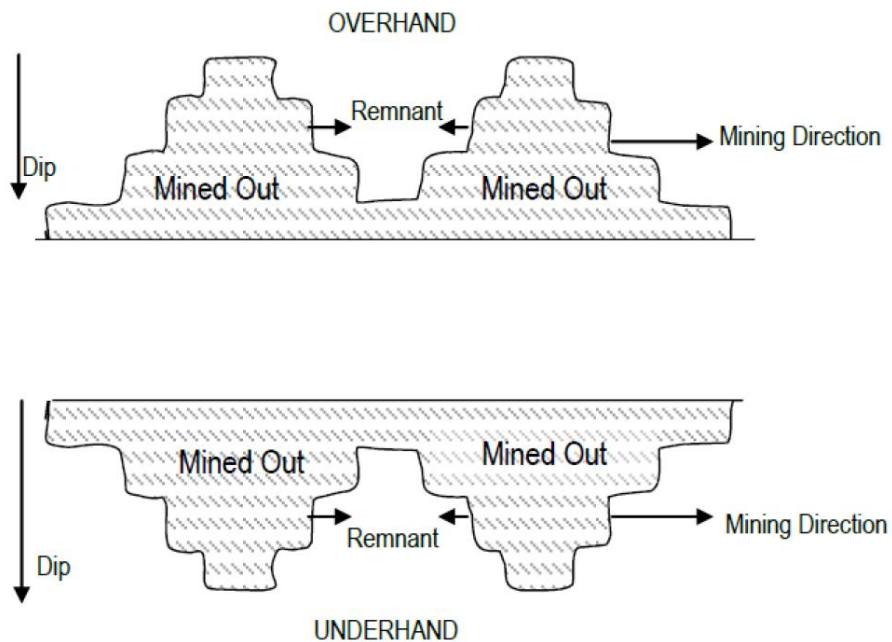
5.1.2 Re-establish the face after the panel collapsed:

(3)

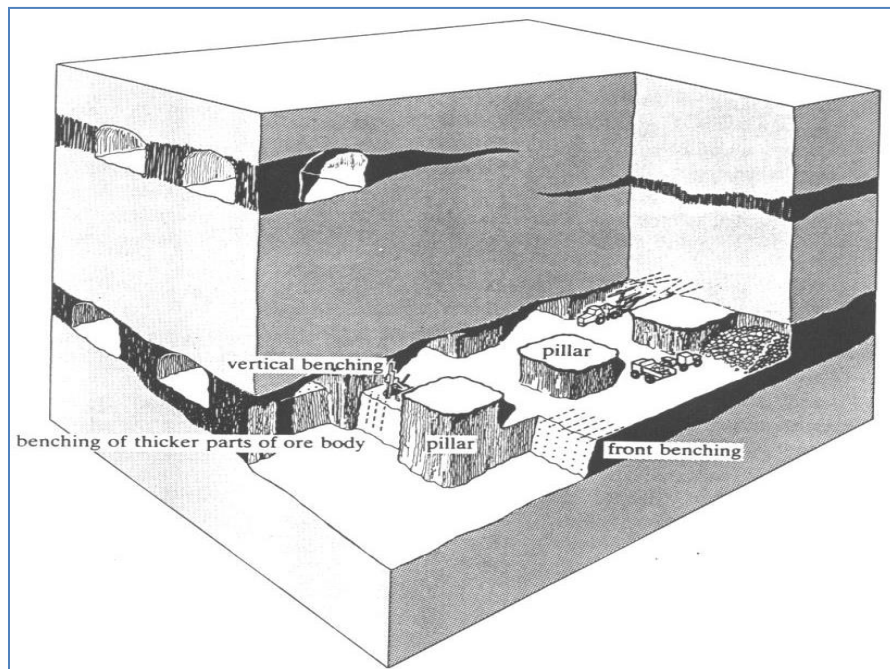


A represents pillar dimension and b wide raise width

5.2 Draw an underhand and overhand mining configuration. Annotate sketches clearly.



5.3 Describe the mining method Room and Pillar mining with the aid of a sketch. Pay attention, type of ore body, support and when is this method selected. (8)



Used in:

- Flat-lying ore bodies with an ore dip up to 25°
- Ore body must be relatively shallow to prevent leaving excessive ore in pillars
- Must be fairly uniform with grade for mechanized mining
- Strong competent ore body with low frequency of jointing

Method:

- Ore is produced from room which serves as multiple purposes as access, airway and transport drifts.
- Pillars generated as ore remnants to control roof rock and global response of the rock.
- Pillars are arranged in a regular grid pattern.
- Close performance of roof spans and pillars are required.
- Roofbolts in HW and pillars.
- Pillars can be left permanently or removed on an orderly retreat way by inducing collapse of the immediate roof (backfill to be installed if pillars removed).
- Minimal off reef development, roadways established inside production stopes and mined out stopes serve as transport roads.

5.4 Describe the mechanism of breaking rock by explosives indication the importance of stemming, burden, hole length and hole diameter. (6)

Stemming is used in a blast hole as a plug to prevent the blowout of a blasthole. It is often a clayish material with enough strength to confine the explosives in the hole and to allow the explosive energy to be transferred into rock mass, thus into breaking the rock. Using effective stemming could reduce explosives consumption significantly, since only 50 percent to 66 percent of the shothole then requires to be filled with explosives.

Burden is the distance between top holes measured along the face, and also the vertical distance between top and bottom holes. The correct burden will ensure proper breaking of the rock, along the entire length of the panel, making it easier to clean and support the panel.

The **length of the hole** drilled should be approximately the same as the stoping width (on narrow reef). It is extremely important that all holes be drilled to the same depth so as to ensure an even break of the rock, and leaving a straight panel, which is easy to clean and support. Mminimize the damage to the hangingwall and to the installed support.

Hole diameter plays an important role with regards to the amount of explosives can be inserted into the hole. Overcharging can result in damage to hangingwall.

[20]

QUESTION 6 – GEOLOGY

6.1 Briefly describe how sedimentary rocks, metamorphic rocks and igneous rocks are formed. Give an example of each rock type. (6)

Sedimentary Rocks

Processes such as weathering, corrosion and corrosion result in the **soils and pre-existing rocks** near earth's surface being changed or broken down. These particles are transported by wind and water and subsequently **deposited**. In a favourable locality these **deposits are built up in layers** to form sedimentary rocks.

Examples: **sandstone, mudstone and shale, conglomerates and breccia's, limestone and coal.**

Metamorphic Rocks

Pre-existing rocks that undergo a **change in texture or mineral content or both** as a result of high **temperature** (thermal metamorphism) or **high pressure** (dynamic metamorphism) or **both** (dynamothermal metamorphism) are called metamorphic rocks.

Examples: **quartzite, marble, hornfels, slate, phyllite, schist, gneiss, migmatite.**

Igneous Rocks

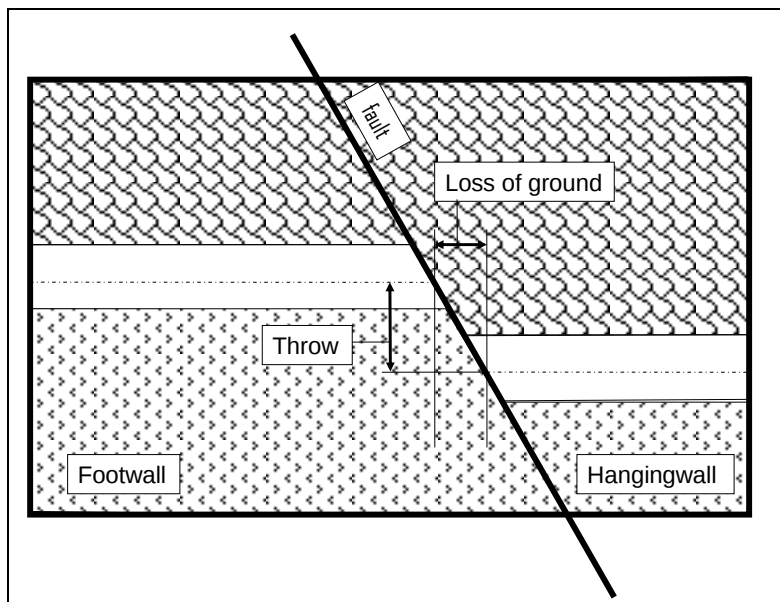
Igneous rocks are those that have **solidified** from **molten material** (magma).

Examples: **granite (biotite, muscovite, hornblende), syenite, diorite (andesite) gabbro (norite, anorthosite, pyroxenite dolerite, basalt), peridotite (dunite, kimberlite).**

- 6.2 With the aid of annotated sketches, describe a normal fault, a reverse fault, strike, true dip and apparent dip. (No Sketches no points) (9)

Normal fault

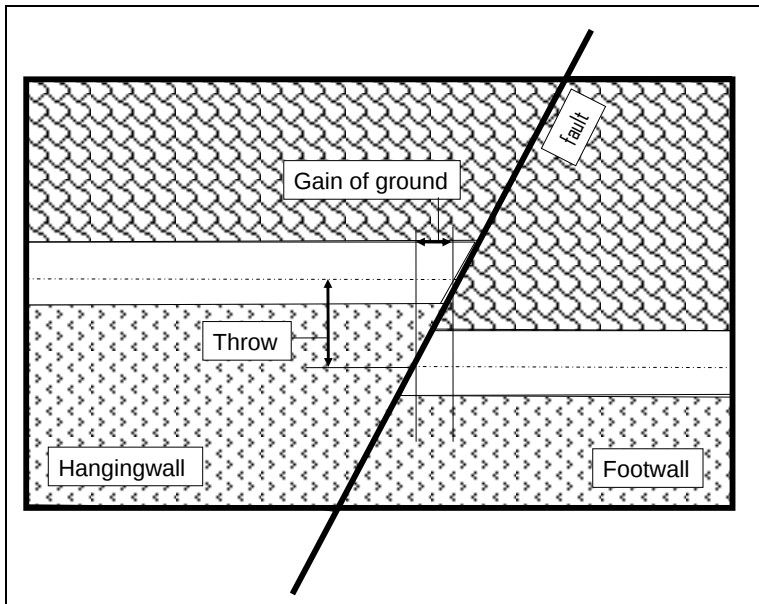
A fault is a naturally occurring **plane of fracture** across which there is **relative movement**. A normal fault results in a '**loss of ground**'.



Normal fault

Reverse fault (3 marks)

A fault is a naturally occurring **plane of fracture** across which there is **relative movement**. A reverse fault results in a '**gain of ground**'.



Reverse fault

True Dip (1 mark)

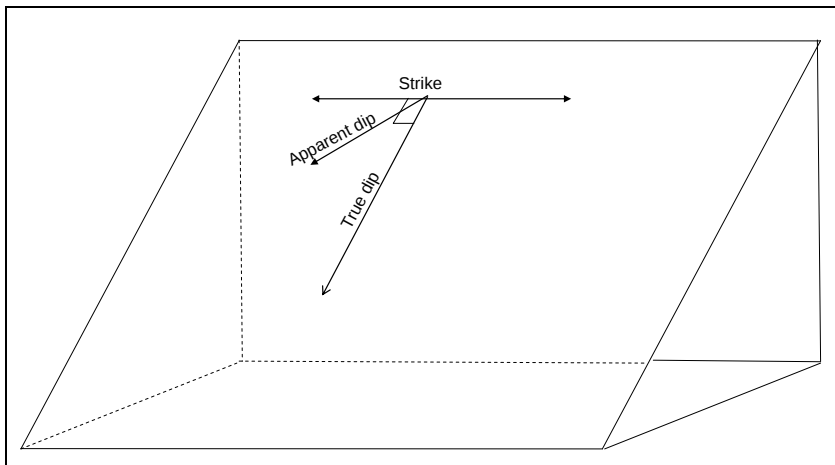
Dip (true dip, major dip) refers to the **steepest slope** of an **inclined stratum**. This is always described by a direction (always down dip) and the angle between the horizontal and the bedding plane.

Apparent dip (1 mark)

Apparent (minor dip) is **any inclination other true dip** along an inclined stratum.

Strike (1 mark)

Strike is the line joining points of equal elevation and is the **direction** along an inclined plane in which the **dip is zero**. Strike and the direction of true dip are always at right angles to each other.



Sketch of strike, dip and apparent dip

APPENDIX A

FORMULE SHEET

1. Total Energy = $\frac{1}{2} m v^2 + mgh$
2. $s_z = \frac{2(1-\nu)q}{G} \sqrt{l^2 - x^2}$
3. $l_c = \frac{s_m G}{2(1-\nu)q}$
4. $\sigma_s = 7.2 \frac{R_0^{0.5933}}{V^{0.0667}} \left\{ \frac{0.5933}{\varepsilon} \left[\left(\frac{R}{R_0} \right)^\varepsilon - 1 \right] + 1 \right\} MPa$
5. $e = 1 - \frac{w_1 w_2}{C_1 C_2}$
6. $ERR = \frac{\Delta U_m}{\Delta A} = \frac{\pi(1-\nu)lq^2}{2G}$
7. $\nu_p = \sqrt{\frac{\lambda + 2G}{\rho}} \quad \nu_s = \sqrt{\frac{G}{\rho}}$
8. $RCF = \frac{3\sigma_1 - \sigma_3}{F\sigma_c}$
9. $RQD = \frac{\sum \text{lenght of core pieces} > 10cm}{\text{total lenght of core}} \times 100$
10. $\frac{h}{s} = \frac{1}{\sqrt{\frac{8h}{s} - 6}}$
11. $Q = RQD/J_n \times J_r/J_a \times J_w/SRF$
12. $G = \frac{E}{2(1+\nu)}$
13. $\tau = \sigma n \tan(\emptyset + JRC \log \tan(\frac{JCS}{\sigma n}))$
14. $APS = q_v/(1-e)$
15. $\varepsilon = \Delta l / L$
16. $E = \sigma/\varepsilon$
17. $\nu = \varepsilon_r / \varepsilon_a$

$$18. \quad P_s = K w^{0.46} / h^{0.66}$$

$$19. \quad P_s = K w^{0.5} / h^{0.75}$$

20. Salamon

$$FS = 288 \frac{w^{2.46}}{Hh^{0.66}(w+b)^2}$$

21. D Merwe

$$S = 3.5 \left(\frac{w}{h} \right) (MPa) \quad L = \frac{25 H C^2}{w^2}$$

22 Squat

$$\sigma_s = 7.2 \frac{R_0^{0.5933}}{V^{0.0667}} \left\{ \frac{0.5933}{\varepsilon} \left[\left(\frac{R}{R_o} \right)^\varepsilon - 1 \right] + 1 \right\} \quad L = \frac{25 H C^2}{w^2}$$