Minerals Council of South Africa

EXAMINATION PAPER

SUBJECT: CERTIFICATE IN ROCK MECHANICS **PAPER 2:** BASIC ROCK MECHANICS PRACTICE **SUBJECT CODE:** COMRMC **DATE:** 08 OCTOBER 2025 **TIME**: 14H00 TO 17H00	**EXAMINER:** N Netshivhazwaulu **MODERATOR:** GR Gainsford **TOTAL MARKS:** 100 **PASS MARK:** 60%

NUMBER OF PAGES: 10 (including this one)

EXAMINATION FORMAT: CLOSED BOOK. NO REFERENCES OTHER THAN WHAT ARE PROVIDED ARE ALLOWED.

SPECIAL REQUIREMENTS:

1. Answer all the questions in legible English.
2. Write your ID number (no names) on the outside cover page of each script used and on any graph paper or other loose sheets handed in.
3. Show all calculations and check the 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 black ink on the right-hand page only. Left-hand pages will not be marked.
6. Illustrate your answers using sketches or diagrams wherever possible.
7. Final answers must be given with accuracy 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) is used, as marks will be deducted if the incorrect unit is used, even if the calculated value is accurate.
8. In answering the questions, full advantage should be taken of your practical experience as well as the data given.
9. You are not allowed to contact your examiner or moderator regarding this examination.
10. Cell phones and other smart devices are not allowed on your person and must be handed to the invigilators or left in your vehicle.

QUESTION 1. PILLAR DESIGN

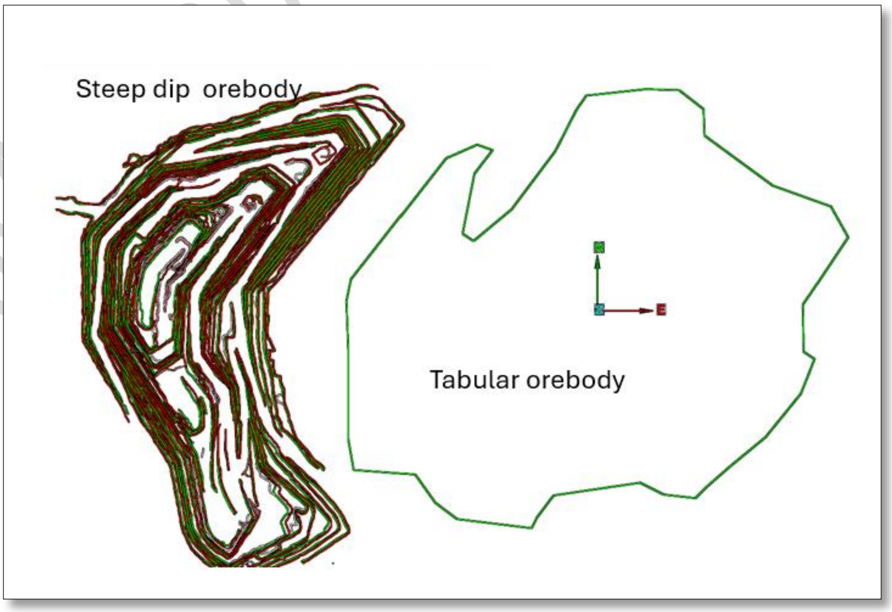
At an intermediate-depth mining operation situated in the northern Free State, management had embarked on a programme to expand its run-of-mine (ROM) production capacity. In order to support this planned increase in production, the operation was in the process of developing a return airway (RAW). This RAW was designed to connect into an existing tunnel, which in turn provided access to a newly-sunk ventilation shaft. The ventilation infrastructure was considered critical to the safe and sustainable expansion of the mine's production profile. During a planning review meeting, a point of contention arose between the production and technical disciplines. According to the mining manager, the RAW was supposed to be holed without any delay. However, the ventilation engineer cautioned that the RAW should not yet be holed, since the construction of a series of pressure-control doors had not yet been completed. As it could create serious safety risks by allowing uncontrolled airflow. Despite these concerns, the mining manager maintained that holing should go ahead to keep the production project on track. She proposed leaving behind a small plug in the RAW that could serve as a temporary ventilation seal until the pressure-control doors were in place. At this point, as the rock engineer, you entered the discussion to provide a geotechnical perspective. You emphasised that if a plug was to be left in place, its stability and performance would be largely dependent on its design.	
1.1. Describe two risks of holing a ventilation drive before all seals or plugs are in place.	(4)
1.2. Describe three different pillar categories according to their w:h ratio and their application or purpose.	(6)
1.3. Given that the tunnels are driven to a width of 5m W x 5m H through the Pyroxinites of UCS 180MPa and 3100kg/m^3 in density at a depth of 970m below surface. 1.3.1. Which type of pillar must your plug resemble? Why? 1**.3.2.** Determine the safe size of the pillar which will meet the requirements of the ventilation engineer and mine manager. The given pillar formula assumes that the tributary area theory holds. Clearly state any further assumptions should you make them and show all your workings. $Strength = k\frac{w_e^{0.5}}{h^{0.75}}\,\mathrm{MPa}$ Where k equates to half the UCS.	 (2) (13)
	[25]

QUESTION 2. LAYOUTS AND MINE SEISMICITY

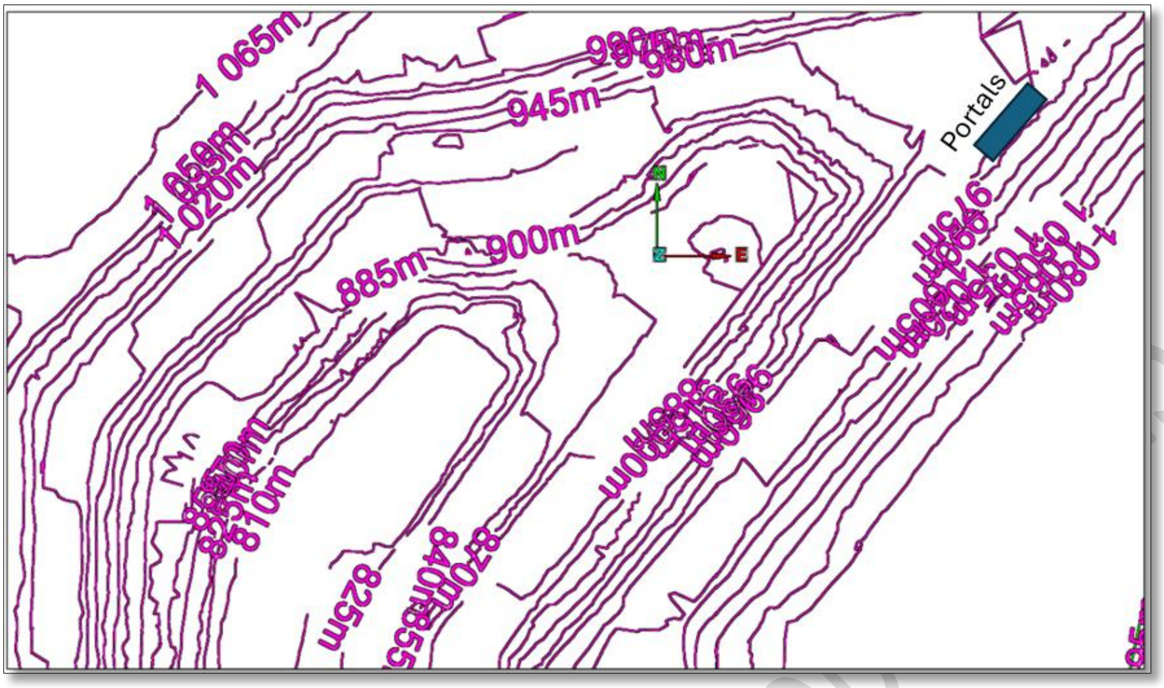
Discuss how regional **mining layouts –** for example, **scattered breast mining** and **sequential grid mining** affect the **energy release rate (ERR)** and seismic hazard in South African deep-level tabular mining. Your answer should also incorporate the concepts of pre-conditioning, non-yielding and crush pillars, and backfill. Your response should:	
• Explain the mechanisms by which layout choices alter stress redistribution and ERR. (10)	(10)
• Evaluate and contrast scattered and sequential mining layouts, highlighting their advantages, disadvantages, and practical underground constraints.	(10)
• Conclude with three evidence-based recommendations to reduce damaging seismicity while maintaining acceptable exposure.	(5)
	[25]

QUESTION 3. SURFACE AND RISK MANAGEMENT

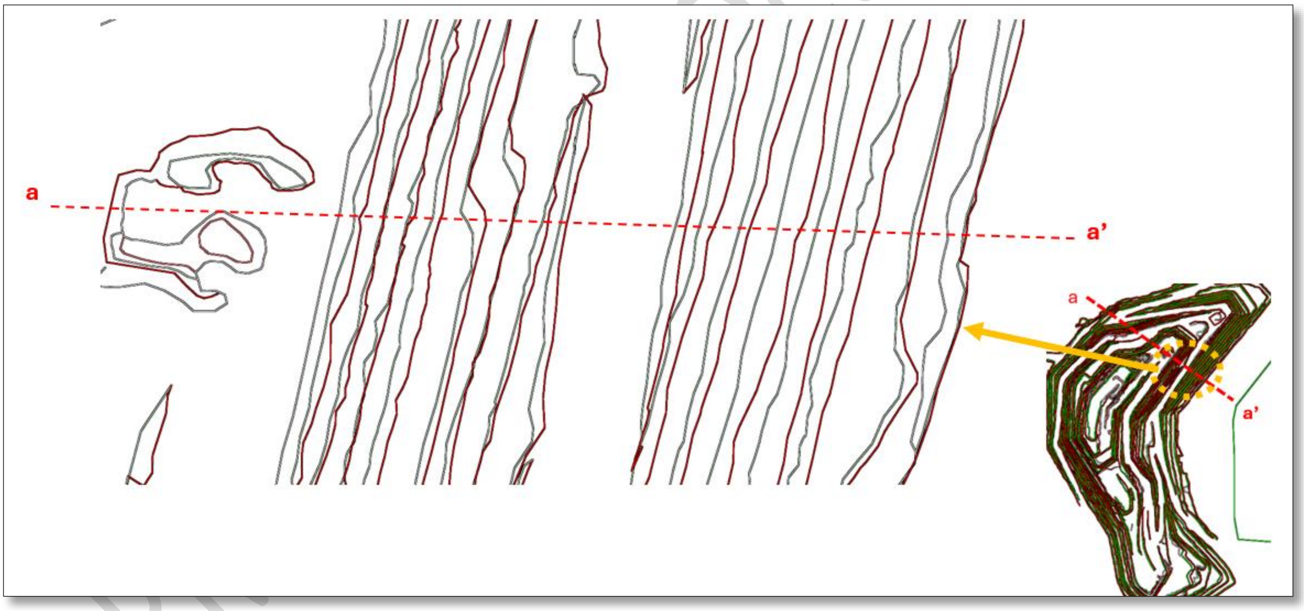
The Khai Pit has been extracting ore from a massive, thick, and steeply dipping orebody and has now reached its maximum depth. Recent exploration efforts to extend the mine's life have uncovered a new orebody adjacent to the pit. In contrast to the exhausted deposit, this discovery consists of a deeper, massive deposit up to a depth of 980m below surface. Two Portals (6m x 6m) spaced 14m apart will be driven to access.



Khai-Pit Limit



Khai-Pit topo contours



Khai-Pit limit zoom-in

As a newly appointed rock engineer, you have joined a project team conducting a feasibility study on mining a tabular orebody. The preferred extraction method is a combination of drifts and fill and sub-level open stoping. The rock mass classification within the portal area revealed good ground condition with an MRMR of 78 and rock type UCS of 233Mpa.

3.1. Draw and label a cross-section view (not to scale) along lines a-a'? (5)

3.2. What is the depth of the portal position and the bottom of Khai pit?	(2)
3.3. Name and describe any blasting techniques which may be implemented on the final highwall to minimise blast damage on the rock mass before developing portals.	(5)
3.4. How would such portals be supported and monitored? Give three examples each.	(3)
3.4. Describe, in a summarized form, the Geotechnical Risk Management Framework which you would recommend for the underground operation?	(10)
3.4. The stope walls in one section under investigation trend N–S (000°/180°) and dip 85° E. Detailed structural mapping reveals the following joint sets: Joint Set 1: 030°/80° SE Joint Set 2: 120°/60° SW Joint Set 3: 270°/70° N The in-situ stress field is characterised by a major horizontal stress trending E–W. The joints are smooth and planar with occasional water inflow along them. a) Name and briefly describe two common structurally bound failure modes on open stope walls. (2) b) Perform a kinematic analysis for the stope face using stereographic projection principles. Determine which modes of failure are kinematically feasible given the joint orientations and stope geometry. (8)	(10)
	[35]

QUESTION 4. NUMERICAL ANALYSIS

<table>
<tr><td>

4.1. Provide a brief theory of the rock engineering application of the following methods:

a) Finite Element Method

b) Finite Difference Methods

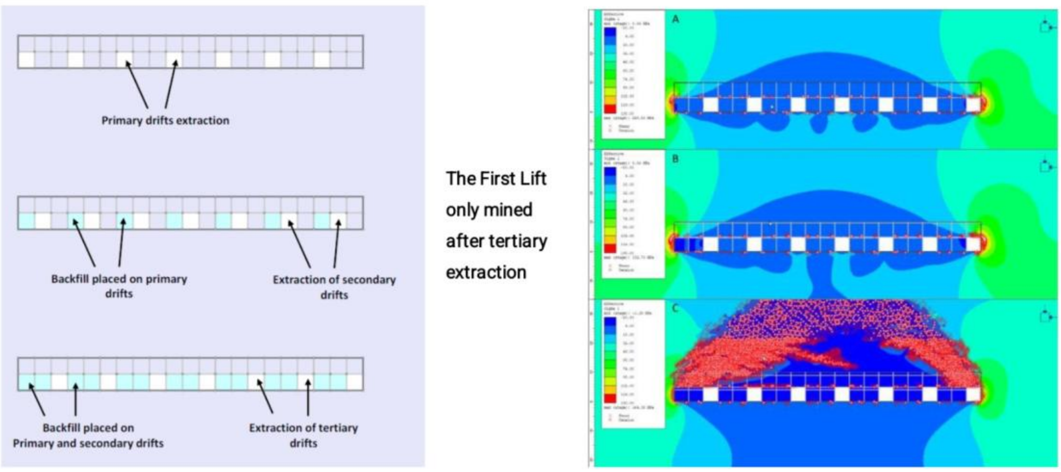
c) Limit Equilibrium Methods

d) Boundary Element Methods

e) Keyblock Methods

</td><td>(5)</td></tr>
<tr><td>

4.2. A conceptual finite-element study was conducted to assess the effect of tight filling on backfill performance in primary, secondary, and tertiary stopes as successive lifts are mined. Three sequencing scenarios (A, B, C) were modelled to illustrate the differences.



- A – Extremely effective backfill tight fill
- B- Expected backfill tight fill
- C- Poor tight filling simulated.

a) Give one example of finite-element modelling software suitable for underground geomechanics.

b) Analyse the model outputs and prepare a brief interpretation for the Mining Manager comparing Scenarios A–C.

Your comparative interpretation must address:

- Hangingwall Damage
- Induced stresses
- Implications for seismic risk

</td><td>(1)

(9)</td></tr>
</table>

	[15]

Total Marks = [100]

FORMULA SHEET

$\sigma_1 = \sigma_3 + \sqrt{(s\sigma_c^2 + m\sigma_c\sigma_3)}$

$\sigma_1 = \sigma_c + \beta_o\sigma_3$

$$\varepsilon_3 = \frac{[\sigma_3 - \nu(\sigma_1 + \sigma_2)]}{E}$$

$$\sigma_1 = \sigma_3 + \sigma_{ci}\left(m_b \frac{\sigma_3}{\sigma_{ci}} + s\right)^a$$

$$\sigma_1 = \sigma_3 + \sigma_{ci}\sqrt{m_i \frac{\sigma_3}{\sigma_{ci}} + 1}$$

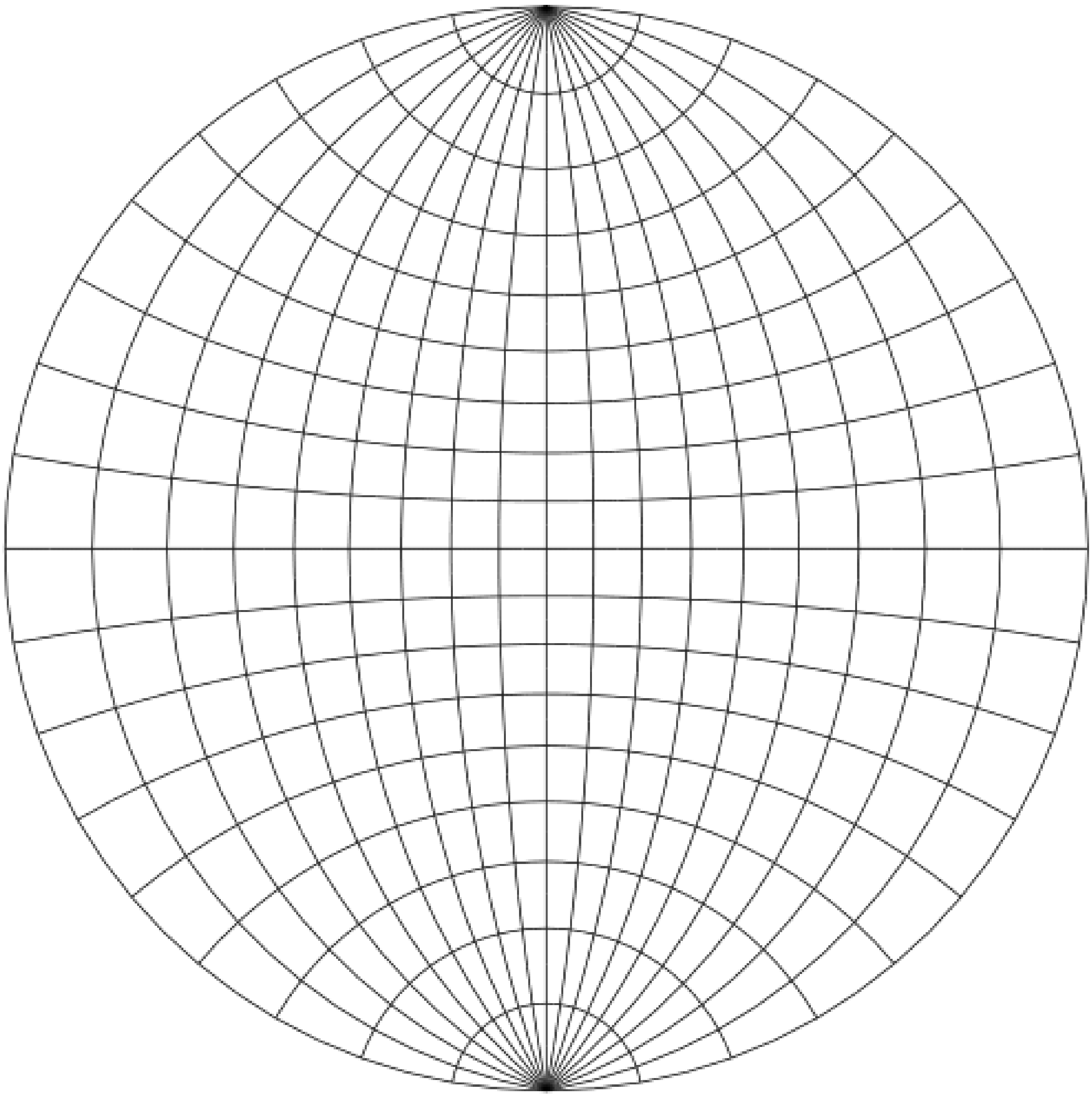
$$\tau = C_o + \mu\sigma_n$$

$$\tau_{max} = \frac{1}{2}(\sigma_1 - \sigma_2)$$

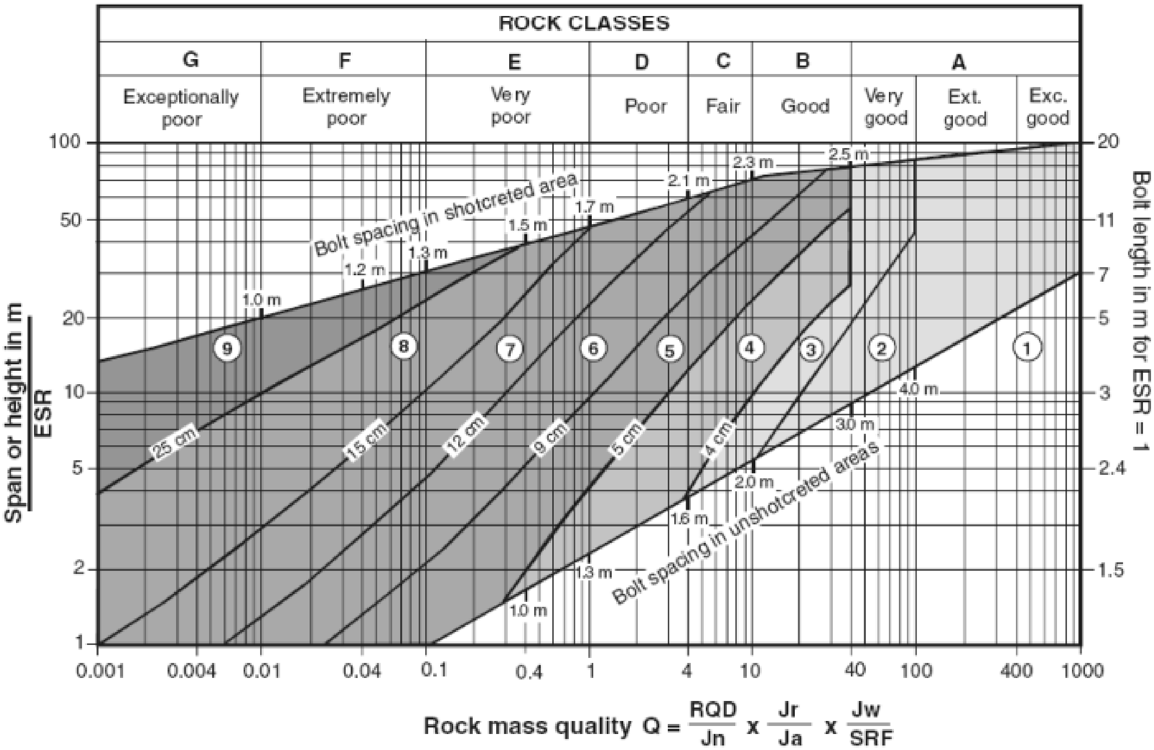
$$\tau = \sigma' \tan\left(\phi + \text{JRC}\log_{10}\left(\frac{\text{JCS}}{\sigma'}\right)\right)$$

$$\phi_j \approx \tan^{-1}\left(\frac{J_r}{J_a}\right)$$

Appendix 1: **ID no__________________________**



Appendix 2: Grimstad & Barton Chart ID No_________________



REINFORCEMENT CATEGORIES:

1) Unsupported
2) Spot bolting
3) Systematic bolting
4) Systematic bolting, (and unreinforced shotcrete, 4 - 10 cm)
5) Fibre reinforced shotcrete and bolting, 5 - 9 cm
6) Fibre reinforced shotcrete and bolting, 9 - 12 cm
7) Fibre reinforced shotcrete and bolting, 12 - 15 cm
8) Fibre reinforced shotcrete, > 15 cm, reinforced ribs of shotcrete and bolting
9) Cast concrete lining