UNIVERSITY OF JOHANNESBURG

Memo

FACULTY OF SCIENCE

DEPARTMENT OF GEOLOGY

MODULE:
ENGINEERING GEOLOGY 2B (GLGB2B2) FOR CONSTRUCTION MANAGEMENT

CAMPUS: DFC

JANUARY 2021 SUPPLEMENTARY EXAMINATION

DATE: 20/01/2021	**SESSION: 11:30 – 14:30**
ASSESSOR:	**Mr. F. E. D. SENZANI**
MODERATOR:	**Dr. D. H. ROSE**
DURATION: 3 HOURS	**TOTAL MARKS: 200**

NUMBER OF PAGES: 21

INSTRUCTIONS:

1. ANSWER ALL THE QUESTIONS IN SECTIONS A AND B BUT ANY FIVE IN SECTION C.
2. USE THE NUMBERED ALLOCATED SPACES ON THE ANSWER SCRIPT TO WRITE YOUR RESPONSES.
3. USE ONLY INK FOR ALL TEXT AS WELL AS SKETCHES.
4. ONLY SHORT, BULLETED ANSWERS ARE NECESSARY FOR THE QUESTIONS IN SECTION C.
5. YOUR INITIALS AND SURNAME (AS ON YOUR STUDENT CARD) AND STUDENT NUMBER MUST BE WRITTEN CLEARLY IN SEPARATE BLOCK CAPITALS (UPPER CASE) ON THE ANSWER SCRIPT.

THESE ARE INSTRUCTIONS FOR SECTION A ONLY:

On the answer script, write, <u>IN FULL</u>, <u>"TRUE"</u>, for a correct statement, and <u>"FALSE"</u>, for an incorrect one. Do <u>NOT</u> use abbreviations "F" for "FALSE" or "T" for "TRUE". The mark for each question is 0.5 while the total for the section is 25. Use the table on PAGE 13 to enter your answers.

1. The appearance of a mineral exposed to light is known as its lustre. F
2. Minerals in the salic group are generally denser than those in the mafic group. F
3. Biotite, muscovite and phlogopite are members of the feldspar group of minerals. F
4. Pyrite is an example of the sulphide group of minerals. T
5. Chemical breakdown of rocks is known as disintegration. F
6. The mineral quartz is harder than feldspar. T
7. A doline appears suddenly as a steep-sided hole, whereas a sinkhole is a gentle surface depression. F
8. Kaolinitic clays are derived largely from the decomposition of microcline/orthoclase. T
9. Bentonite is derived from the disintegration of plagioclase feldspar. T
10. The larger the soil particles, the higher the strength of that given soil. T
11. Soil derived from peridotite returns a good nutritional value for agricultural purposes. T
12. A coarse-grained igneous rock composed of alkali feldspars with quartz as the essential minerals is known as diorite. F
13. If the silica content of a magma is relatively very low, the magma is said to be acidic. F
14. In a basic magma that is cooling down slowly, sodium-rich feldspar will crystallise before potassium-rich feldspar. T
15. A dyke is an igneous rock in the form of a sheet that cuts along the structural planes of the surrounding rocks. F
16. Dolerite is an igneous rock composed essentially of pyroxene and plagioclase. T
17. The micas are characterized by a perfect basal cleavage. T
18. Sodium-rich feldspar is known as arnothosite. F
19. Calcareous sedimentary rocks may be characterized by high contents of carbonate. TRUE
20. Increases in temperature and pressure cause solid-state mineralogical changes in rocks in the process known as lithification. F
21. Serpentinisation is an example of a hydration reaction during chemical weathering. T

22. Calcite is the major component in limestone. T

23. Mechanical breakdown increases the surface area of a rock, thus enhancing decomposition of minerals in the rock. T

24. Gabbroic rocks weathers to kaolinitic-rich soils giving rise to light coloured and non-fertile soil. F

25. The electrostatic attraction forces between grains influence cohesion in soil. T

26. Natural exposures of rocks are known as stones. F

27. In a thrust fault, the hanging wall (block) moves downwards relative to the footwall along the fault-plane. F

28. In a strike fault, the footwall moves upwards along the fault-plane. F

29. Oblique faults display both strike-slip and dip slip along the fault plane. T

30. Increase in distance between soil particles will generally increase the Van der Waal's forces between particles. F

31. A uniform-grain size sandstone bed has a lower porosity than another with cement filled intergranular voids. F

32. When an aquifer is placed against an aquiclude across a fault which reaches the surface below the water table, an artesian spring is produced. F

33. Shear strength is controlled by the cohesion of soil material. T

34. Rock mass is the term used to describe the intact rock between discontinuities. F

35. The tensile strength of a rock is the maximum tensile stress (tension force) that a rock can withstand before failure. T

36. A sandstone with calcareous cement is stronger than one with an equal amount of siliceous cement. F

37. Rock structure is the nature and distribution of planar features within the rock mass. T

38. Dykes are vertical or steep narrow intrusions of generally fine-grained igneous rocks of igneous origin that may vary in width from a few centimetres to several metres. T

39. Lichens and moss can grow on rocks and breakdown the rock by chemical means. F

40. Plutonic igneous rocks such as diorite are strong and can therefore support steep excavations. T

41. Excavations made at right angles to the strike of steeply dipping strata are less stable than those made along the strike. T

42. Gently dipping strata form wedges in the roof which may collapse into the tunnel. T

43. A doline is a depression that forms slowly over time. T

44. Slabbing may occur in a tunnel cut in a direction parallel to the strike of steep joint sets. T

45. Additional stress caused by the weight of water in a dam is too low to cause failure in the rocks forming the base or walls of the dam. F

46. The only characteristics required for rip-rap are that the rock must be fresh and not be prone to rapid decomposition. T

47. The oldest rocks in South Africa belong to the Limpopo Metamorphic Province. F

48. The Onverwacht Group is composed of the oldest rocks of the Ventersdorp Supergroup. F

49. The Limpopo Mobile Belt is the record of the earliest plate tectonic continental collisions in the South African geology. T

50. The Witwatersrand Supergroup was deposited in an intracratonic basin. T

INSTRUCTIONS FOR SECTION B ONLY

Select the correct or best answer. There is only one correct or best response for each question. Each question carries 1 mark; total 50 marks. Use the answer sheet provided on PAGE 13 to indicate the letter of the correct response.

51. The structure of the earth is partly determined by using the following, the only exception is
    (A) earthquake waves.
    (B) meteorite composition.
    (C) the composition of the sun.
    (D) none of the above, they all apply.

52. The following form parts of the solid earth, but not
    (A) tectonic plate.
    (B) lithosphere.
    (C) biosphere.
    (D) outer core.
    (E) upper mantle.

53. The mantle of the earth is rich in
    (A) silicon and oxygen.
    (B) magnesium and iron.
    (C) iron and nickel.
    (D) aluminium and silicon.
    (E) none of the above.

54. Geology involves the study of
    (A) earth structures.
    (B) earth processes.
    (C) earth materials.
    (D) all of the above.
    (E) none of the above.

55. The margins of a tectonic plate may be
    (A) zones of extension.
    (B) zones of shear.
    (C) zones of collision.
    (D) all of the above.
    (E) none of the above.

56. Parts of the Earth's lithosphere are known as tectonic
    (A) segments.
    (B) sectors.
    (C) portions.
    (D) none of the above.

57. This element is not a parent isotope used in the dating of rocks:
(A) potassium.
(B) uranium.
(C) rubidium.
(D) nitrogen.
(E) none of the above, they are all used.

58. In three half-lives, the remainder of a parent isotope would be
(A) ½ of the original.
(B) ¼ of the original
(C) ⅛ of the original
(D) none of the above.

59. The following are physical properties which may be used to distinguish minerals:
(A) colour
(B) reflectance
(C) smell
(D) (A) and (B)
(E) all of the above
(F) none of the above

60. The softest mineral on Moh's Scale of Hardness is
(A) gypsum.
(B) talc
(C) fluorite.
(D) diamond.

61. Nepheline and leucite are examples of
(A) feldspars.
(B) micas.
(C) amphiboles.
(D) none of the above.

62. Orthoclase and microcline are examples of
(A) feldspathoids.
(B) olivines
(C) feldspars.
(D) all of the above.
(E) none of the above

63. Olivines are common in
(A) acid igneous rocks.
(B) ultramafic rocks.
(C) intermediate igneous rocks.
(D) (A) and (B).
(E) (B) and (C).
(F) none of the above rocks.

64. A perfect single cleavage is characteristic of this group of minerals
(A) micas.
(B) quartz.
(C) pyroxenes.
(D) amphiboles
(E) none of the above

65. Igneous rocks are formed when
(A) magma temperature rises.
(B) metamorphic rocks are brought to the surface.
(C) sedimentary rocks are melted.
(D) magma cools down and crystallises.
(E) all of the above
(F) none of the above

66. This feature is not used in the classification of igneous rocks:
(A) grainsize.
(B) content of silica.
(C) content of carbonate.
(D) none of the above.

67. In Bowen's Reaction Series depicting crystallization of a basic magma, as temperature decreases
(A) minerals rich in silica crystalize last.
(B) minerals rich in magnesium crystalize last.
(C) minerals rich in sodium crystalize last.
(D) minerals rich in potassium crystalize last.
(E) none of the above

68. When a basic magma crystallises, the last minerals to form are rich in
(A) Fe
(B) K
(C) Mg
(D) (a) and (b)
(E) none of the above

69. Gabbros differ from granites primarily in
(A) grain size.
(B) mineral composition
(C) level of intrusion
(D) none of the above

70. The Ventersdorp lavas are examples of
(A) intrusive rocks.
(B) hypabyssal rocks.
(C) extrusive rocks.
(D) (A) and (B).
(E) none of the above.

71. Granites are coarse-grained equivalents of
(A) basalt.
(B) rhyolite.
(C) andesite.
(D) none of the above.

72. The rocks below are examples of mechanically-derived sedimentary deposits except
(A) siltstone.
(B) sandstone.
(C) conglomerate.
(D) calcrete.

73. The odd-one-out in the list below is
(A) coal.
(B) graphite
(C) diamond
(D) augite

74. This rock is not an evaporite:
(A) calcrete.
(B) dolocrete
(C) silcrete
(D) ferricrete
(E) concrete
(F) none of the above.

75. The rocks below are igneous rocks, except
(A) rhyolite.
(B) diorite.
(C) dunite.
(D) quartzite

76. When …….. undergoes increasing temperature at low pressure, it forms a hornfels.
(A) shale
(B) sandstone
(C) conglomerate
(D) limestone
(E) silcrete

77. The metamorphic style, likely to introduce new structures in rocks, is
(A) contact metamorphism.
(B) dynamic metamorphism.
(C) regional metamorphism.
(D) all of the above.
(E) none of the above.

78. The term "strike" refers to
(A) the maximum inclination of any planar structure in a rock.
(B) the compass direction of the tilt of a linear structure in a rock.
(C) the inclination of a linear feature of a rock.
(D) none of the above

79. The axis of a fold
(A) is bent to form the two limbs.
(B) bisects the angle between the fold limbs.
(C) is a horizontal line on one of the limbs.
(D) all of the above.
(E) none of the above.

80. Strike-slip faulting occurs on a fault with
(A) horizontal movement alone.
(B) vertical movement alone.
(C) combined vertical and horizontal components.
(D) all of the above
(E) none of the above.

81. A fold is isoclinal when
(A) the limbs dip in opposite directions with equal angles
(B) when the limbs dip in opposite directions at different angles.
(C) when the limbs dip in in the same directions at different angles.
(D) none of the above.

82. A fold is plunging when its axis is
(A) vertical.
(B) horizontal.
(C) neither vertical nor horizontal.
(D) parallel to the strike of the limbs.
(E) none of the above.

83. The use of rocks as construction materials began
(A) to reinforce bunkers during the First World War.
(B) at the beginning of the 20th Century.
(C) at the beginning of the industrial revolution.
(D) after cutting and polishing tools became available.
(E) none of the above

84. The …….. divide sedimentary rocks into beds or strata
(A) bedding planes
(B) faults
(C) cross bedding
(D) lamination

85. A coarse grained clastic sedimentary rock is likely to have high porosity if
(A) the proportion of interstitial spaces is high.
(B) the particles are angular.
(C) the particles are close packed.
(D) all of the above.
(E) none of the above.

86. Porosity in a sandstone depends partly on
(A) grain size distribution.
(B) the packing of grains.
(C) the amount of cement
(D) all of the above.
(E) none of the above.

87. Sedentary soils may be found
(A) on top of the basaltic source rocks.
(B) on top of the rhyolitic source rocks.
(C) on top of porphyritic source rocks.
(D) on top of gneissic source rocks.
(E) all of the above
(F) none of the above

88. Bentonite clays are produced from the breakdown of
(A) mafic rocks.
(B) intermediate rocks.
(C) felsic rocks.
(D) all of the above.
(E) none of the above.

89. Kaolinitic clays are typical of the weathering of this rock:
(A) granite.
(B) granophyre.
(C) rhyolite.
(D) all of the above.
(E) none of the above.

90. Rock mass refers to
(A) a body of rock including its discontinuities.
(B) a body of intact rock without any discontinuities.
(C) the weight of the rocks being studied.
(D) all of the above.
(E) none of the above.

91. Soils are stronger if
(A) they have high moisture content.
(B) they have high cement content.
(C) they have a high confining pressure.
(D) the grains are rounded.
(E) none of the above.

92. Bieniawski's rock mass rating (RMR) system of classification uses the
(A) condition of groundwater.
(B) Stress Reduction Factor (SRF).
(C) spacing of joints.
(D) (A) and (B) only
(E) (A) and (C) only
(F) all of the above

93. These rocks are listed in their order of decreasing mechanical strength:
(A) sandstone, siltstone, shale.
(B) siltstone, shale, sandstone.
(C) shale, sandstone, siltstone.
(D) shale, siltstone, sandstone
(E) none of the above

94. These rocks are listed in their order of decreasing mechanical strength:
(A) diorite, diorite-porphyry, andesite.
(B) andesite, diorite-porphyry,diorite.
(C) andesite, diorite, diorite-porphyry.
(D) diorite-porphyry, andesite, diorite.
(E) none of the above

95. If a horizontal tunnel is driven along a synclinal axis, water drains along the bedding planes
(A) outward from the tunnel.
(B) inward into the tunnel.
(C) down in the direction of the tunnel slope.
(D) all of the above
(E) none of above.

96. These divisions of South African rocks are listed in their order of increasing age:
(A) The Transvaal Supergroup, the Karoo Supergroup, the Ventersdorp Supergroup and the Bushveld Complex.
(B) The Bushveld Complex, the Transvaal Supergroup, the Karoo Supergroup and the Ventersdorp Supergroup.
(C) The Ventersdorp Supergroup, the Bushveld Complex, the Transvaal Supergroup, the Karoo Supergroup.
(D) None shows the correct order.

97. The Transvaal Sequence was deposited between.
(A) 2 Ga and 1.8 Ga
(B) 2.2 Ga and 2.0 Ga
(C) 3.0 Ga and 2.6 Ga
(D) none of the above

98. If a tunnel is driven in a direction parallel to axis of a syncline,
(A) the walls are prone to failure
(B) the walls are stable.
(C) this does not any impact on the stability on the wall.
(D) the roof undergoes overall extension
(E) none of the above.

99. This feature is not important in the assessment of a construction site:
(A) rock types.
(B) soil composition.
(C) depth of the water table.
(D) the structure of the rocks.
(E) none of the above.

100. In thinly bedded and vertically jointed horizontal strata, the failure of the roof blocks is known as
(A) blocking.
(B) overbreak.
(C) fallout.
(D) all of the above
(E) none of the above

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ANSWER SHEET FOR SECTION A AND B

SECTION A - TRUE/FALSE QUESTIONS		SECTION B – MULTIPLE CHOICE QUESTIONS	
1	26	51	76
2	27	52	77
3	28	53	78
4	29	54	79
5	30	55	80
6	31	56	81
7	32	57	82
8	33	58	83
9	34	59	84
10	35	60	85
11	36	61	86
12	37	62	87
13	38	63	88
14	39	64	89
15	40	65	90
16	41	66	91
17	42	67	92
18	43	68	93
19	44	69	94
20	45	70	95
21	46	71	96
22	47	72	97
23	48	73	98
24	49	74	99
25	50	75	100

INSTRUCTIONS FOR SECTION C ONLY

Answer any FIVE questions. Use the numbered corresponding spaces on the answer script. Any later answers after the first five will be ignored and be awarded a ZERO.

Give only brief answers. Only "bullet" points, preferably one per line, or clearly separated if on the same line, need be given. The questions carry equal marks – Total: 125 marks.

101. You are informed, that the site targeted for a new University of Johannesburg campus, falls in an area underlain by jointed pure dolomite. There is therefore the prospect of formation of sinkholes.

(A) Place, in their CORRECT ORDER, the list of processes of occurrence, during sinkhole formation. **(20 marks)**

NUMBER	*CORRECT ORDER*	*PROCESS*
1	7	Creation of caverns/voids at joint intersections in pure dolomite
2	5	Dissolution of jointed pure dolomite
3	8	Lowering of water table
4	11	Failure of rock and soil above carverns and formation of sinkholes
5	2	Hot and humid climatic period
6	1	Presence of jointed pure dolomite
7	10	Drainage of soil from joints into caverns below
8	3	Development of a high/shallow water table
9	9	Drying and shrinkage of soil above caverns
10	6	Hot and arid climatic period
11	4	Carbonatisation of carbonate concentrated at joint intersections in pure dolomite

(B) What steps would you take to ensure that the phenomenon mentioned in 101 (A) does not negatively impact the foundations of the campus during or after construction? **(5 marks)**

- acknowledge
- map
- geophysics
- drill
- fill

102. An area is underlain by gabbroic igneous rocks. During weathering, clays are produced.

(A) Select the processes which will occur in the formation of the clays. Insert the work 'yes' or 'no' in the right column. N. B. Some of the processes do not apply and should not be selected. **(8 marks)**

NO.	*PROCESS*	*DOES THIS PROCCESS OCCUR (YES OR NO)?*
1	Weathering in alkaline aqueous conditions	NO
2	Formation of montmorillonitic clay	YES ✓
3	Formation of kaolinitic clay	NO
4	Presence of granitic rocks	NO
5	Breakdown of potassic feldspar	NO
6	Breakdown of plagioclase feldspar	YES ✓
7	Weathering in acidic aqueous conditions	NO
8	Presence of gabbroic rocks	YES. ✓

(B) In what order do the processes selected in 102(A) occur. Use the NUMBERS in the left column to indicate from the first to the last e. g. 7, 5, 9, 1, 6, 4, 2, , ,. Use ONLY THE ONES SELECTED IN 102(A). **(8 marks)** 6, 6, 2 ?

NO.	*PROCESS*
1	Weathering in alkaline aqueous conditions
2	Formation of montmorillonitic clay
3	Formation of kaolinitic clay
4	Presence of granitic rocks
5	Breakdown of potassic feldspar
6	Breakdown of plagioclase feldspar
7	Weathering in acidic aqueous conditions
8	Presence of gabbroic rocks

(C) Are there any problems to be anticipated if you have to lay foundations over the clayey soils mentioned in 102 (B)? If so, describe the problem and how they are caused. swelling of clays **(3 marks)**
→ deformed foundations → failure of building

(D) Mention the steps you would take to avert the potential problems, if you mentioned any in 102 (C). remove clay **(6 marks)**
block water ingress ; build on platform

103. There are two tunneling projects, one through a homogenous granite, and the other in a region of steeply dipping sandstone strata, which are well indurated and cemented by silica. The average thickness of the sandstone strata is much shorter than the width of the tunnel.

(A) Enter a 'yes' or 'no" to indicate, in the right column, the characteristics of the granite described, which add to the stability of the tunnel in the list below. **(11 marks)**

NUMBER	*GRANITE CHARACTERISTIC*	*DOES IT ADD TO STABILITY (YES OR NO?)*
1	It is a strong rock	YES
2	It is a weak rock	NO
3	It is homogenous in mineral composition	YES
4	It is a coarse grained rock	YES
5	It is a fine grained rock	NO
6	It is composed of angular grains	~~TRUE~~ YES
7	It is composed of rounded grains	~~FALSE~~ NO
8	It has an interlocked grain fabric	~~TRUE~~ YES
9	It has a tangential fabric	NO
10	It has homogenous structure/It is structureless	~~Tkt~~ YES
11	It is split by bedding planes	NO
12	The bedding is dipping steeply	NO

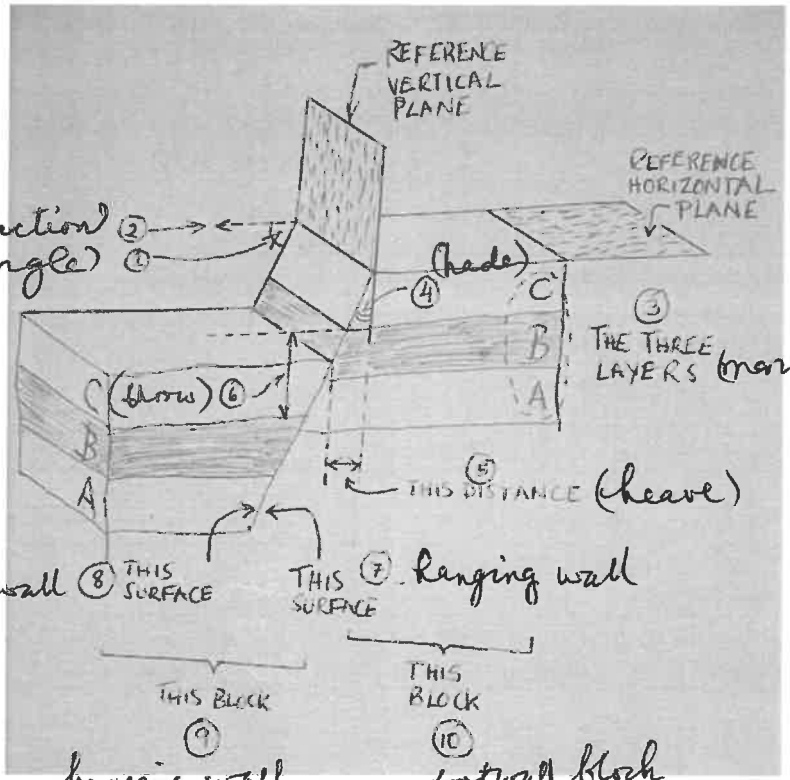
(B) In the list below, select the characteristics of the described sandstone, which increase the stability of the tunnel. **(11 marks)**

NUMBER	*SANDSTONE CHARACTERISTIC*	*DOES IT ADD TO STABILITY (YES OR NO?)*
1	It is a strong rock	YES
2	It is a weak rock	NO
3	It is homogenous in mineral composition	YES
4	It is a coarse grained rock	NO
5	It is a fine grained rock	YES
6	It is composed of angular grains	NO
7	It is composed of rounded grains	YES
8	It has an interlocked grain fabric	NO
9	It has a tangential fabric	YES
10	It has homogenous structure/It is structureless	NO
11	It is split by bedding planes	YES
12	The bedding is steep	YES

(C) In terms of increased stability, which rock type would you prefer to locate the channel, and why? Granite – Stronger – uniform **(3 marks)**

104. Fault situation.

(A) What kind of fault is shown in the sketch below? **(2 marks)** normal



hanging wall block (downfaulted).

footwall block (upfaulted)

(B) What features distinguish it from other fault types/How is it defined? **(4 marks)**
- fault-dip direction
- hw/or fw block movement relative to each other

(C) Name all the parts of the fault numbered 1 to 10. **(10 marks)** see diagram

(D) Consider tunneling from the footwall side towards the hanging wall side in the first case, and approaching the fault from the opposite direction, in the second case: compare the stability of the roof and indicate if there which of the two options you would encourage, and why. **(9 marks)**

- from footwall block roof wedge not detected till too late - danger of roof failure due to roof wedge
- also inflow of water ± debris from h/w block
- fault detected in floor 1st.
- roof failure can be anticipated
- inflows of water + debris also a danger
- tunnelling from h/w preferred; roof failure is a greater danger.

105. You are given a list of four rocks, namely, granite, sandstone, shale and limestone.

(A) Give a brief description of each i. e. what are they? **(8 marks)**
2 each

(B) Imagine that you have to make an open road excavation though each of the rocks, and in every case, and for this purpose

(i) make a list of the positive characteristics of the rocks. **(8 marks)**

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(ii) make a list of the negative characteristics of the rocks. **(9 marks)**

106. For the Karoo Supergroup answer the following questions:

(A) what is the age? **(2 marks)**

(B) where in South Africa is it located? **(4 marks)**

(C) what are the main rock types? **(6 marks)**

(D) looking at each rock type in turn, what should anyone intending to carry out construction in the area underlain by selected unit bear in mind? **(8 marks)**

PTO

(E) looking at each rock type in turn, mention at least one measure, that should be taken to address the concern(s) mentioned in 106(D)? **(5 marks)**

107. Preparations are underway to develop a tunnel. You are supplied with two lists: one of the characteristics of the body of rock to be tunneled (Geomechanical field data), and the other of parameters and their ratings (Reference tables 1 and 2). These appear both below and on the answer sheet. Also accompanying is one graph of RMR/MRMR, and another of the stand-up times of unsupported tunnel spans. Yet another shows the engineering modifications necessary to stabilize the ground.

PTO

Question 107 – Geomechanics field data

Parameter	Description
Rock Quality	Length of drilled core: 280m Length of core +100mm: 260
Joint set detail	Two joint sets
Joint surface description	Slickensided and discontinuous
Joint filling or alteration	Tightly healed, hard, non-softening impermeable rock mineral filling
Joint separation	0mm
Ground water	Dry excavation
Head of water	<10m
Stress reduction factor	Competent rock mass UCS = 225MPa Depth = 1190m, Density = 2755kg/m^3

Question 107 - Reference tables (1 of 2)

Parameter			Ranges of values						
1	Strength of intact material	Point load strength index	>10 Mpa	4-10 Mpa	2-4 Mpa	1-2 Mpa	Use UCS		
		Uniaxial compressive strength	>250 Mpa	100-250 Mpa	50-100 Mpa	25-50 Mpa	5-25 Mpa	1-5 Mpa	<1 Mpa
	Rating		**15**	**12**	**7**	**4**	**2**	**1**	**0**
2	Drill core quality (RQD)		90-100%	75-90%	50-75%	25-50%	<25%		
	Rating		**20**	**17**	**13**	**8**	**3**		
3	Spacing of joints		>2m	0.6-2m	200-600mm	60-200mm	<60mm		
	Rating		**20**	**15**	**10**	**8**	**5**		
4	Condition of joints		very rough surfaces; not continuous; no separation; no weathered rock	slightly rough surfaces; separation <1mm; slightly weathered walls	slightly rough surfaces; separation <1mm; highly weathered walls	slickensided surfaces, or gouge <5mm-thick or separation 1-5mm; continuous	soft gouge >5mm thick or separation >5mm; continuous		
	Rating		**30**	**25**	**20**	**10**	**0**		
5	Groundwater	Inflow per 10m tunnel length (litres per minute)	None	10	10-25	25-125	>125		
		Joint-water pressure or major principal stress (Mpa)	0	0.0-0.1	0.1-0.2	0.2-0.5	>0.5		
		General conditions	Completely dry	Damp	Wet	Dripping	Flowing		
		Rating	**15**	**10**	**7**	**4**	**0**		

Question 107 - Geomechanics reference tables (2 of 2)
– Adjustments to RMR for orientation of excavation relative to discontinuities –

					Rating
6	Strike perpendicular to excavation axis	Advance of tunnel with dip	Dip 45° to 90°	Very favourable	0
			Dip 20° to 45°	Favourable	-2
		Advance of tunnel against dip	Dip 45° to 90°	Fair	-5
			Dip 20° to 45°	Unfavourable	-10
	Strike parallel to excavation axis		Dip 45° to 90°	Very unfavourable	-12
			Dip 20° to 45°	Fair	-5
	Dip 10° to 20° irrespective of strike		Dip <20°	Fair	-5

(A) **Determine the Q-Value, TO ONE DECIMAL PLACE,** Given that

Q-Value = RQD x Jr x Jw x Jw / (Jn x Ja x Ja x SRF),

and RQD = the Rock Quality Designation

Jr is the Joint Roughness Number

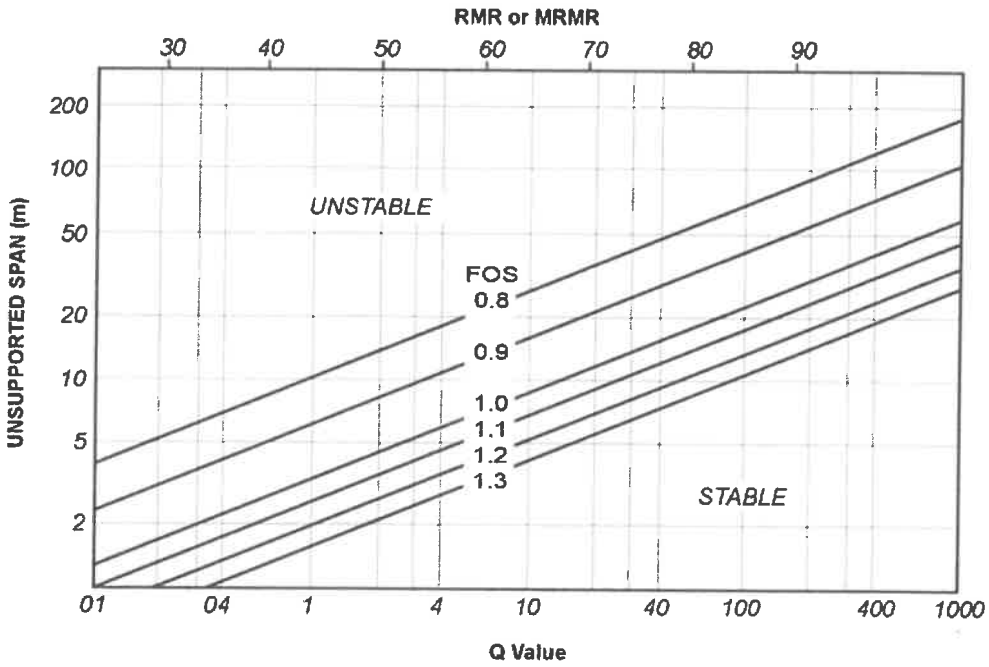
Jw is the Joint Water Reduction Factor

Jn is the Joint Set Number

SRF is the Stress Reduction FactoR. **(10 marks)**

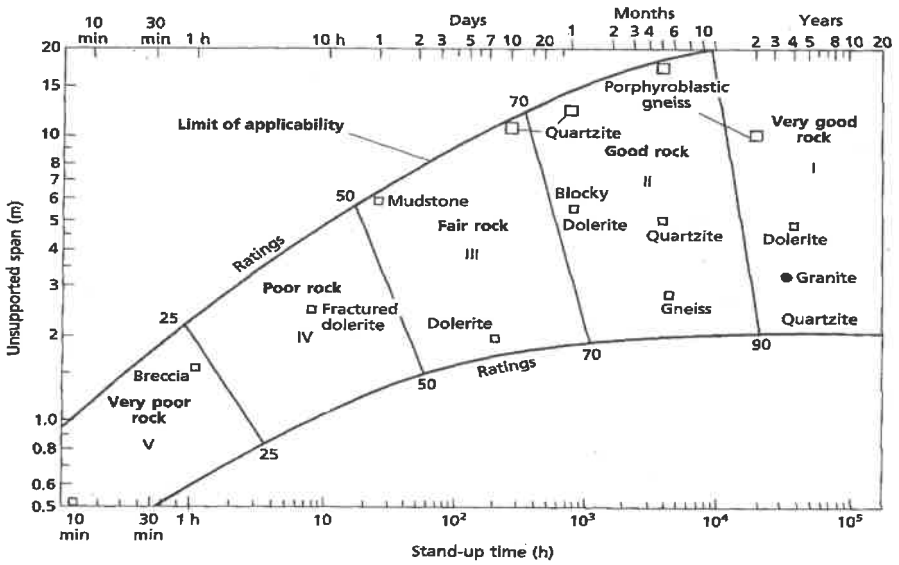
(B) What is the equivalent Bieniawski rock mass rating (RMR) for the Q-Value just worked out, given that RMR = 9 x lnQ + 44? **(2 marks)**

(C) On the figure below, plot the RMR or Q-value, and determine the factor of safety (FOS) for a tunnel 5 metres wide. **(2 marks)**



(D) On the diagram below, plot the RMR on the graph of the stand-up times of a 5m-wide unsupported span.

(2 marks)



Geomechanics classification of rock masses for tunnelling. South African case studies are indicated by squares

(E) For a span of 5m, determine the stand-up time of an unsupported tunnel.

(2 marks)

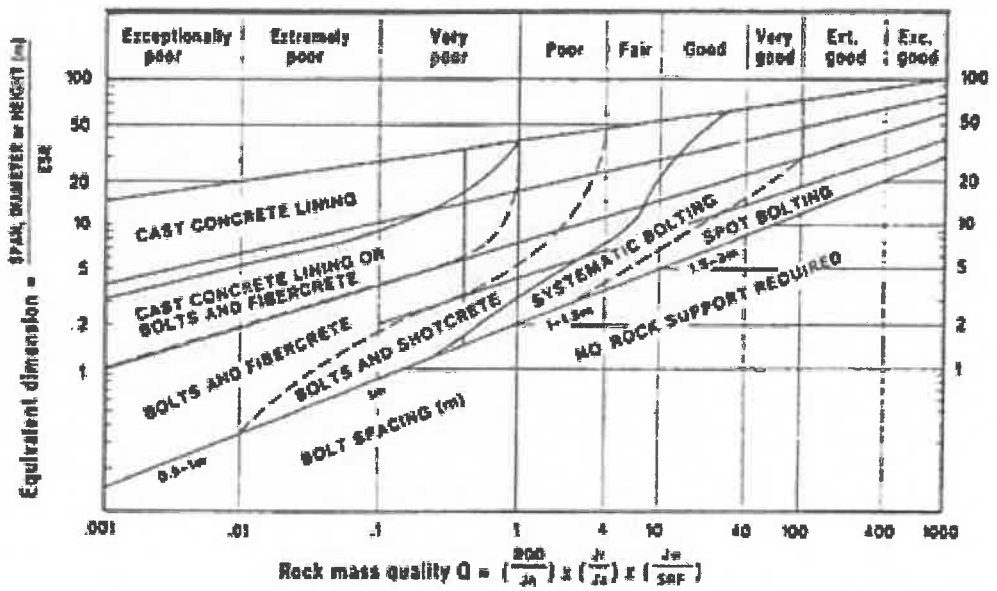
(F) Will the FOS and Stand-Up-Time increase or decrease if the tunnel span is changed to 15m? **(2 marks)**

F) You are informed that the tunnel is 12m wide and for an underground nuclear station. Use the table of Equivalent Support Ratios (ESR) for Different Excavations, to determine the correct Equivalent Dimension (ED) where ED = Span/ESR.

(2 marks)

Table 9.7 Equivalent support ratio for different excavations

Excavation category	ESR
1 Temporary mine openings	3–5
2 Vertical shafts:	
Circular section	2.5
Rectangular/square section	2.0
3 Permanent mine openings, water tunnels for hydropower (excluding high-pressure penstocks), pilot tunnels, drifts, and headings for large excavations	1.6
4 Storage caverns, water treatment plants, minor highway and railroad tunnels, surge chambers, access tunnels	1.4
5 Power stations, major highway or railroad tunnels, civil defence chambers, portals, intersections	1.0
6 Underground nuclear power stations, railroad stations, factories	0.8



(G) What is the preventative work necessary for the excavation to be stable. Use the diagram above. **(2 marks)**

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105.

A. granite - igneous, coarse, essential K-feldspar & quartz

sandstone - sed, mechanically derived, med-grain, mostly rounded quartz, feldspar (K), micas and some clay minerals

shale - sed, mech derived, v. fine grained, quartz, clay, mica

limestone - sed, chemically or organically derived, calcite dominated, fine, may be shelly.

B(i) granite - ~~strong~~ ~~coarse~~ - due to coarseness, ~~sorting~~ grain interlocked fabric and mineral & chemical uniformity, stable minerals

sandstone - strong to moderately strong, strong/stable minerals

shale - no positive features as a foundation/ excavation slopes

limestone - hard, uniform

B(ii) granite - difficult to excavate, may have zones of hydrothermal weathering, which are weak

sandstone - may have low % cement ∴ weaker, rounding of grains → weakness, bedding planes,

shale - easy to excavate, bedding

106. A. 350 – 150 Ma

B. All provinces

C. Sandstone, conglomerate, shale, tillite, coal, arkose, dolerite, basalt, rhyolite

D. Sandstone – cement, angularity – bedding

Conglomerate – " " "

Shale – qtz-clay ratio, bedding, ~~weak~~ low strength

Tillite – see congl

Coal – mechanically weak

Arkose – see sandstone

Dolerite, basalt, rhyolite } strong due to interlocking + uniformity

Basalt, dolerite } possible swelling clay

107. ~~(A)~~ (A) 0·6

(B) 39

(C) 1.1

(D) I

(E) increase

(F) 2

(G) bolts & fibercrete