



FACULTY OF SCIENCE

DEPARTMENT OF GEOLOGY

MODULE CODE	GLG2A01
MODULE NAME	Igneous Rocks
CAMPUS	APK
EXAM	MAY 2016

Date	30 May 2016
Assessor(S)	Prof Marlina Elburg
Internal Moderator	Prof Hassina Mouri
External Moderator	
Duration	180 minutes
Marks	100

Number of pages **5 (including front page)**

Instructions **Answer all the questions**

If I cannot read your handwriting, the answer is wrong. Marks are also deducted if you do not follow the instructions of the question, for misspelling of the names of rocks and minerals, and for nonsense (so a combination of a correct answer and a grossly incorrect statement is not going to earn you full marks). When the question asks to 'explain' something, you will have to give your line of reasoning!

Note that there is an equation sheet at the back that also contains the outline of useful diagrams.

Final Exam GLG2A01 May 2016 Student number:

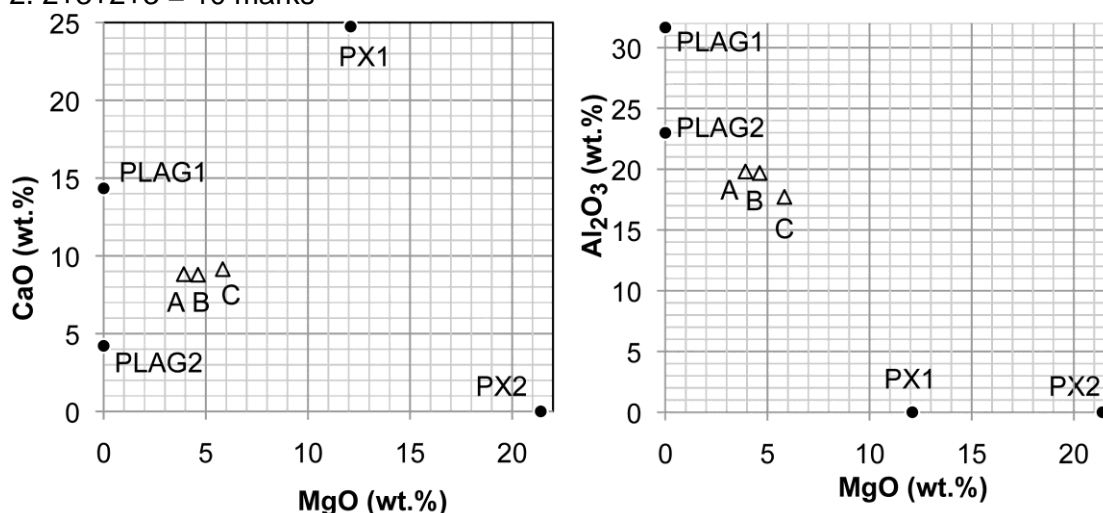
Total marks: 100

1. 10 marks

	Ba	Sr
plagioclase	0.2	2
sanidine	4	1

A magma differentiates by crystal fractionation (Rayleigh fractionation, fractional crystallisation) of plagioclase and sanidine. The proportions in which these two minerals fractionate is plagioclase: sanidine = 1:2. The mineral melt/distribution coefficients are given in the table above. The starting magma contains 500 ppm Ba and 100 ppm Sr. What is the Ba/Sr of the more evolved magma, formed by the removal of 45% crystals? Show your calculations.

2. 2+3+2+3 = 10 marks

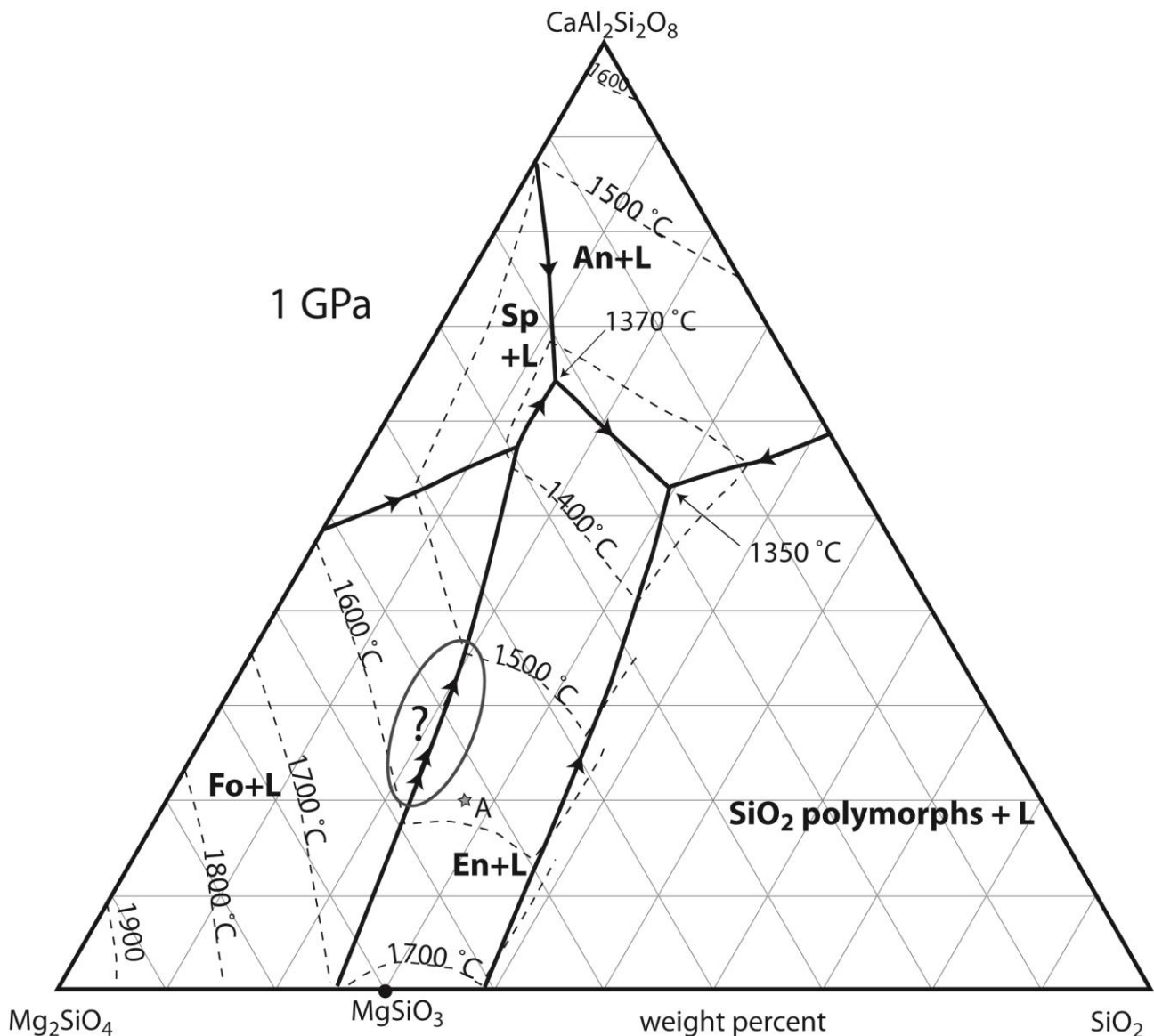


Three magmatic rocks (A, B and C) are likely related to each other by crystal fractionation.

1. Explain which of these three is the least evolved, and therefore the parental magma to the two others.
2. To obtain the first daughter magma (daughter1) from the parental magma, two pyroxenes are thought to fractionate (PX1 and PX2). What are their percentages in the fractionating assemblage? Show in the diagrams how you derived your answer.
3. Explain why the two pyroxenes have such different compositions.
4. To get from daughter1 to daughter2, which is more evolved than daughter1, a pyroxene and a plagioclase fractionate. Which combination of PX1, PX2, PLAG1 and PLAG2 are fractionating, and what are their percentages in the fractionating assemblage? Explain and show in the diagram how you derived your answer.

3. 10 marks

Explain, with reference to thermodynamic properties, and including a sketch of a P-T diagram, why magma is formed at mid-ocean ridges.



4. (4+2+2+4+3+3+2 = 20 marks)

The diagram above represents the phase diagram for the ternary system Mg_2SiO_4 - SiO_2 - $\text{CaAl}_2\text{Si}_2\text{O}_8$ at 1 GPa. The dashed lines represent isotherms. Answer the following questions, and make sure you show in the diagram how you arrived at your answers:

- As indicated on the diagram, the author pretends to be in great uncertainty whether the curve between the primary phase fields of Fo and En is a cotectic or a peritectic curve. Luckily, you know the answer to this question. Please explain your choice. The explanation will need to involve a tangent to a line, and the intersection of that tangent with another line that is already on the diagram above.
- Given a melt, called A, with a composition of the little star in the diagram above. This melt cools in a closed system, at 1 GPa. At approximately what temperature does the first mineral phase form, and what is the full name of this mineral phase?
- What is the full name of the second mineral phase to form from melt A, and at approximately what temperature does this happen?
- Just before the third mineral phase starts to form from melt A, what are the proportions of the phases present in the system?
- When sample A has cooled to ca. 1300 °C, what are the phases present? List them in order of decreasing abundance.
- Explain whether sample A would be most similar to a peridotite, a basalt, a dacite or a rhyolite.
- Out of the three choices in the previous question that you thought were dissimilar to sample A, plot **two** in their approximate position in the diagram, making clear which symbol represents which rock.

5. 10 marks.

Stratovolcanoes (=composite volcanoes) are typically found in a different plate tectonic setting than shield volcanoes. Explain which is found in which tectonic setting, and why, in as much detail as possible.

6. (6*2=12 marks).

Give the most appropriate IUGS name for the extrusive rocks A-C, and intrusive rocks F-H. If there is more than one possibility, then provide both possible names. Empty diagrams can be found on the next page.

Sample	A	B	C
SiO ₂	42.49	49.56	60.53
TiO ₂	1.01	2.81	0.49
Al ₂ O ₃	15.25	14.05	14.83
FeO*	12.99	12.56	5.2
MnO	0.19	0.18	0.14
MgO	13.5	5.26	3.46
CaO	12.03	6.09	6.44
Na ₂ O	1.5	5.21	4.24
K ₂ O	0.67	3.82	4.55
P ₂ O ₅	0.37	0.45	0.12
total	100	99.99	100

	F	G	H
quartz	0	0	0
plagioclase	44	61	0
orthoclase	11	9	0
leucite	12	0	0
clinopyroxene	19	9	18
orthopyroxene	0	13	20
olivine	0	5	60
amphibole	14	3	2

7. (3+4+3=10 marks)

	S J/molK	V (cm ³ /mol)	H _f ° kJ/mol	G _f ° kJ/mol
Ca ₂ MgSi ₂ O ₇	212.5	92.54	-3864.8	-3667.5
CaMgSi ₂ O ₆	142.7	66.09	-3201.5	-3026.8
MgSiO ₃	66.3	31.3	-1545.6	-1458.3
SiO ₂	41.46	22.69	-910.7	-856.3

The mineral åkermanite (Ca₂MgSi₂O₇) can react with enstatite (see formula given in table) and quartz to give diopside. Thermodynamic data (at STP) are given in the table above.

- Write a balanced reaction.
- Will this reaction take place at STP? Show your calculation.
- Is this reaction endo- or exothermic? Show your calculation.

8. (5+5 = 10 marks)

- Explain which textures and mineral shapes you would look for as an indication that an igneous rock had undergone fast cooling.
- Explain whether you expect to see an amygdaloidal texture in an intrusive rock.

9. (4*2 = 8 marks)

Provide a one-sentence definition of:

- Pahoehoe
- Caldera
- Vitrophyric
- Pyroclastic breccia

Handy equations and other things:

$$\Delta_{rx}G = \Delta_{rx}H - T\Delta_{rx}S$$

$$\frac{dG}{dP} = V$$

$$\frac{dG}{dT} = -S$$

$$\Delta G_{rx, T', P'} = \Delta G_{rx, T_{ref}, P_{ref}} + \Delta V_{rx} (P' - P_{ref}) - \Delta S_{rx} (T' - T_{ref})$$

$$d\Delta G = \Delta V dP - \Delta S dT$$

$$P + F = C + 2$$

$$D_i^{a/b} \text{ (or } K_{di}^{a/b}) = C_i^a / C_i^b$$

$$\frac{C_l}{C_0} = \frac{1}{F + D - FD}$$

$$\frac{C_l}{C_0} = F^{(D-1)}$$

