Exam: Advanced Structural Metamorphic Petrology and Mineralogy 2013
Time: 09.00-12.00

Question 1

A) Give a definition of the eclogite facies.
B) Give a definition of ultra-high pressure metamorphism
C) What are the most important rock types present within an (U)HP metamorphic terrane?
D) Describe a geotectonic model that can explain the dominant rock association described in C.
E) Can you come up with an alternative geotectonic model as described in D?
F) In a new fieldwork area you have discovered the rock types described in C. What do you have to do (describe the action(s)) to decide what model (=answer given in D and/or E etc) is applicable to this new field work area.

Question 2

You are working for a private company. During recent fieldwork you have discovered some important microstructural details about a particular rock sequence. You want to make a report that describes you findings. At present however you are still in a foreign country and the local authorities offer you the usage of the equipment illustrated in Fig 1.

A) What is the name of the research equipment illustrated in Fig 1.
B) What can you do with this equipment?
C) Describe what the numbers 1,2,3,4,5 and 6, given in Fig 1, refer to
D) What determines the resolution of the equipment illustrated in Fig 1.
E) What will be the accuracy of any performed analyses.

Question 3.

A) Give a definition of geothermobarometry?
B) Describe how geothermobarometry works in practice using the hypothetical minerals A: XYZ_2O_6 and $B=X_3Y_2Z_3O_{12}$
C) What is the fundamental assumption in geothermobarometry?
D) Give minimal two examples in which the results, obtained by geothermobarometric calculations using EMP mineral chemical data performed on a <u>large</u> number of different geological samples, allowed you to construct a geological model for a particular metamorphic area/terrane.
E) In your fieldwork area geothermobarometric results indicate that the stable mineral assemblage present in your samples

was formed at T=850°C and P=20 kb. Additional work demonstrated that the latter metamorphic conditions are overprinted by approximately isothermal decompression down to 10 kb/800°C, after that a gradual linear PT path followed down to 0 kb and 0°C.

Recently experimental work has been performed, concerned with the rate of solid state diffusion of particular elements in geological materials. This work has demonstrated that particular elements started to become "mobile" (by diffusion) at T≥700°C. In other words according to these experiments at T ≥ 700°C grains in your sample were still open for element diffusion exchange with their surroundings. Most important the experiments were performed using the same elements as you needed for your geothermobarometric calculations that resulted in the PT conditions during which your stable mineral assemblage was formed (T=850°C and P=20 kb). In other words at T ≥ 700°C the rock forming minerals in your sample were still open for element diffusion exchange with their surroundings.
Describe how these diffusion experiments may (or may not) have effected the obtained PT results of T=850°C/P=20 kb.

F) How can you demonstrate/what can you do (or develop) to demonstrate/prove that the above described late element diffusion effects, described in E, did not occur in your rocks?

Question 4

During the practical sessions you have investigated a heavy sand fraction from Ameland (= practical 10). The same image is given here as Fig 2 but two of the constituent minerals are changed (see Table 1).

A) Use the mineral chemistries given in Table 1 and calculate /work out the backscattered coefficient of each solid phase. A periodic table of the elements is illustrated in Fig 3.
B) Indicate which mineral in Table 1 (numbered 1-4) corresponds with the symbol A, B and C in Fig 2.
C) Is it possible that another mineral is still present in Fig 2? Explain your answer.
D) Outside the field of view given in Fig 2 there is another mineral (called E) that has a (mean) backscatter coefficient that is higher than that of mineral A. What can you say about its grey shade in Fig 2? Will it be possible to discriminate it from A? If so what do you have to do?
E) What type of detector was used to make the image of Fig 2?
F) What is the name for the contrast in Fig 2?

Question 5

Collect a thin section from the box present in front of the room. Write down the number of this thin section on your exam paper (at the onset of question 5) before you start answering the following questions:

A) Describe the mineralogy present in the thin section.
B) Describe the meso- and microstructure.
C) Make a paragenetic diagram.
D) Give the rock a metamorphic name.
E) What is the bulk rock comp of the rock?
F) How can you recognize "equilibrium conditions" in a thin section?

PS: Do not forget to write down your name and student number on the top right side of each paper you are using during the exam

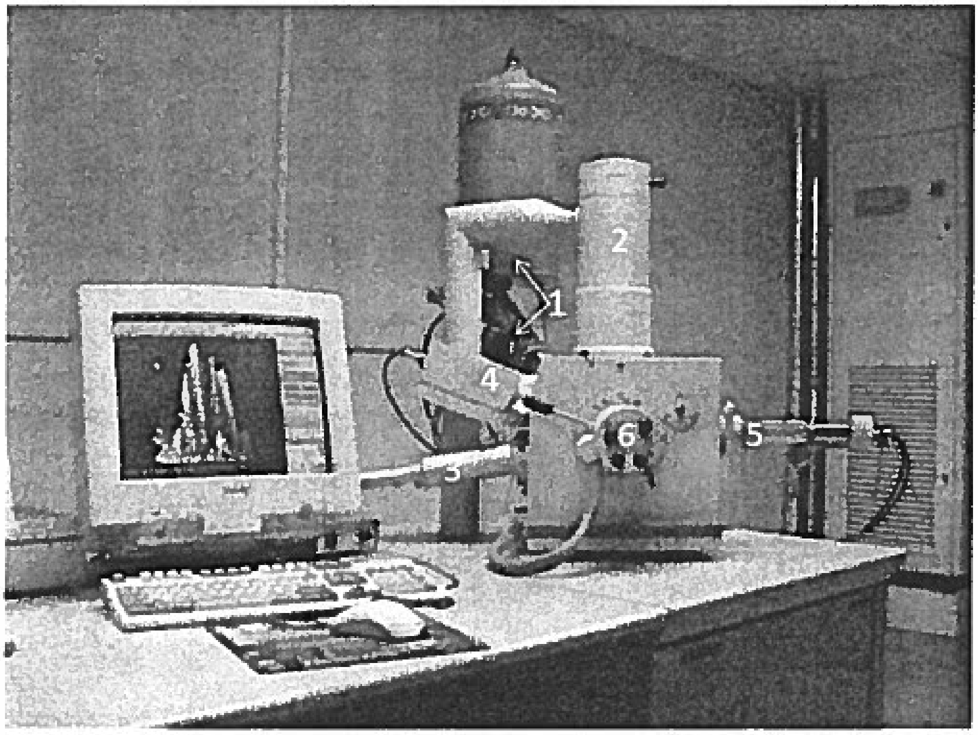

Fig 1

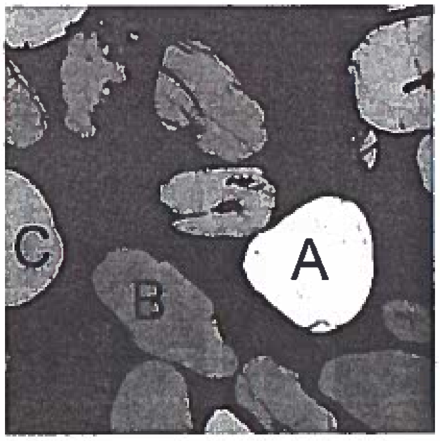

Fig 2

Table 1.
EMP analyses of solid phases A, B, C and D (as illustrated in Fig. 2). Note: The number of cations (SFU) are based upon 4 oxygen atoms for phase 1, 5 oxygen atoms for phase 3 and 12 oxygen atoms for phase 2.

	Oxide Wt %	No. of Cations
Solid phase 1: Olivine $(MgFe)_2SiO_4$		
SiO_2	41.52	1.004
FeO	9.79	0.198
MgO	49.76	1.794
Total	101.07	2.996
Solid phase 2: Garnet $A_3B_2Si_3O_{12}$		
SiO_2	37.24	5.971
Al_2O_3	20.96	3.962
CaO	7.70	1.322
FeO	32.78	4.397
MgO	1.66	0.397
Total	100.33	16.048
Solid phase 3: Andalusite (Al_2SiO_5)		
SiO_2	36.84	0.993
Al_2O_3	63.15	2.007
Fe_2O_3	0.11	0.002
CaO	0.02	0.001
Total	100.12	3.003
Solid phase 4: Galena (PbS)		
Pb	86.66	
S	13.28	
Total	99.94	

Periodic Table of the Elements