Exam Advanced Metamorphic Petrology and Mineralogy 2012

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

- **A)** Use the mineral chemistries given in Table 1 and work out which mineral in Fig 1 now corresponds with the symbols A, B and C?
- **B)** Is it possible that another mineral is still present in Fig 1? Explain your answer.
- **C)** Outside the field of view given in Fig 1 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 1? Will it be possible to discriminate it from A? If so what do you have to do?
- **D)** What type of detector was used to make the image of Fig 1?
- **E)** What is the name for the contrast in Fig 1?

Question 2: 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 2) 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?

Question 3: A vertical cross-section through an electron-optical column of a transmission electron microscope is given in Fig. 2. Answer the following questions:

- **A)** Give names to the parts indicated by number 1-9
- **B)** Describe the function of the parts indicated by the numbers 1-9
- **C)** Which of the numbers 1- 9 are also present in an electron microprobe?
- **D)** Which of the numbers 1- 9 are also present in an optical microscope?
- **E)** Describe the 3 main operational modes of a TEM.
- **F)** Define resolution in a TEM

Question 4: EMP analyses (en calculated structural formulae) of garnet and clinopyroxene are given in Table 2. The structural formulae(SFU) of garnet was calculated for 12 oxygen, while 6 was used for clinopyroxene. Answer the following questions:

A) Calculate for both minerals how much Fe3+ is present in the SFU

B) Plot both analyses in a triangular end member diagram.
Use for garnet

Almandine= $Fe_3Al_2Si_3O_{12}$
Spessartine= $Mn_3Al_2Si_3O_{12}$
Pyrope= $Mg_3Al_2Si_3O_{12}$
Grossular= $Ca_3Al_2Si_3O_{12}$
Andradite= $Ca_3Fe_3{}^{+2}Si_3O_{12}$

And take (Alm+Spess), (Gross+Andr) and Pyr as end members.

Use for clinopyroxene:

Augite = $Ca(MgFe^{2+})Si_2O_6$
Jadeite = $NaAlSi_2O_6$
Acmite = $NaFe^{3+}Si_2O_6$

C) Are the minerals chemically zoned?

D) How can you recognize prograde _and/or_ retrograde metamorphic conditions in triangular diagrams given in B

E) What else can you do to check whether your answers, given in C and D, are correct?

F) Calculate the metamorphic conditions under which the rock was formed using the partition coefficient (Kd) and Jadeite-isoploth graphics given in Fig 3.

G) What are the assumptions made to do the calculations in F

H) Among the stable mineral assemblage of the investigated rock (which contains the minerals illustrated in Table 2) plagioclase occurs. Was does this tell you about the PT conditions calculated in F?

Question 5: Give a definition of the following terms:

A) Ultra high pressure metamorphism
B) Eclogite facies
C) The mineral paragenesis
D) The bulk rock composition
E) Cathodoluminescence
F) A multispectral image
G) Orientation contrast

Fig 1

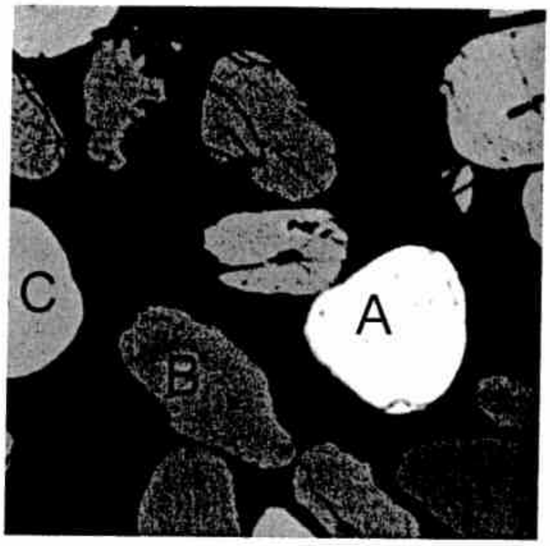


Table 1.
EMP analyses of the solid phases A,B,C and D illustrated in Fig. 1.
Note: The number of cations are based upon 24 Oxygen atoms (for phases 2 and 3) and based on 4.0 Oxygen atoms for phase 1 and 4.

Solid phase 1: olivine $(MgFe)_2SiO_4$

	Oxide Wt %	No. of Cations
SiO2	41.52	1.004
FeO	9.79	0.198
MgO	49.76	1.794
Total	101.07	2.996

Solid phase 2: garnet $A_3B_2Si_3O_{12}$

SiO2	37.237	5.9714
Al2O3	20.956	3.9607
Ca0	7.696	1.3223
FeO	32.784	4.3967
MgO	1.661	0.3970
Total	100.333	16.0482

Solid phase 3: zircon $ZrSiO_4$

SiO2	32.640	5.9886
ZrO2	67.190	6.0114
Total	99.829	12.0000

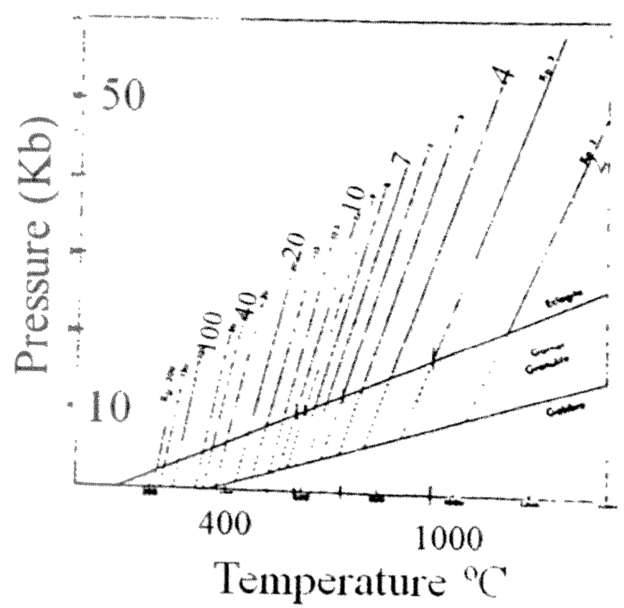
Solid phase 4: xenotime YPO_4

P2O5	38.60	1.092
Y2O3	61.40	0.85
Total	100.00	1.94

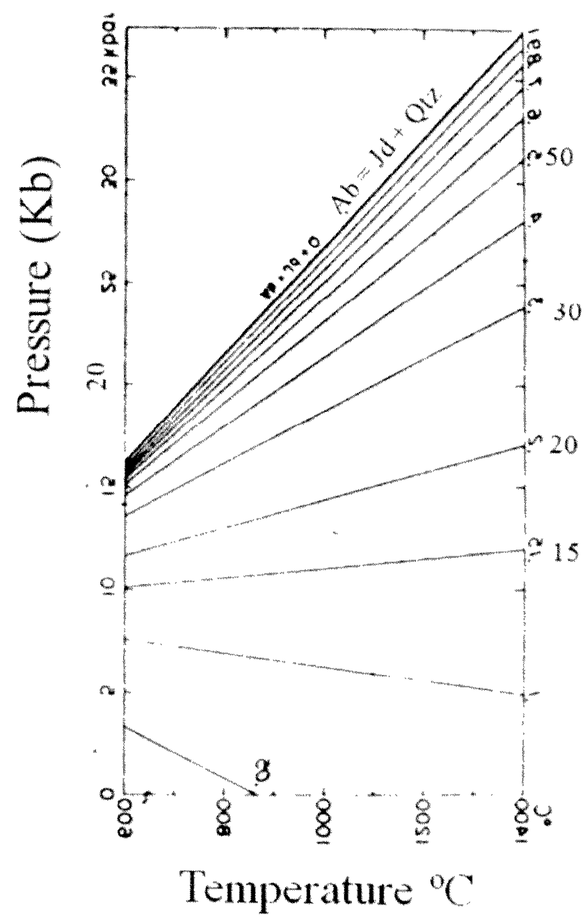
Table 2

garnet		clinopyroxene	
core	rim	core	rim
38,2	38,55	55,66	55,66
21,55	21,55	11,45	11,45
0	0	0	0
27,55	26	4,78	4,78
1,65	0,4	0	0
2,05	5,05	7,5	7,5
9,1	8	12,79	12,79
0	0	7,24	7,24
100,1	99,55	99,42	99,42
3,03	3,02	1,99	1,99
0	0	0,01	0,01
1,99	1,99	0,47	0,47
0	0	0	0
1,85	1,7	0,14	0,14
0,11	0,03	0	0
0,24	0,59	0,4	0,4
0,78	0,67	0,49	0,49
0	0	0,5	0,5
8	8	4	4

Fig 3



$$K_D = \frac{(X_{Fe^{2+}} / X_{Mg})^{GRT}}{(X_{Fe^{2+}} / X_{Mg})^{Cpx}}$$



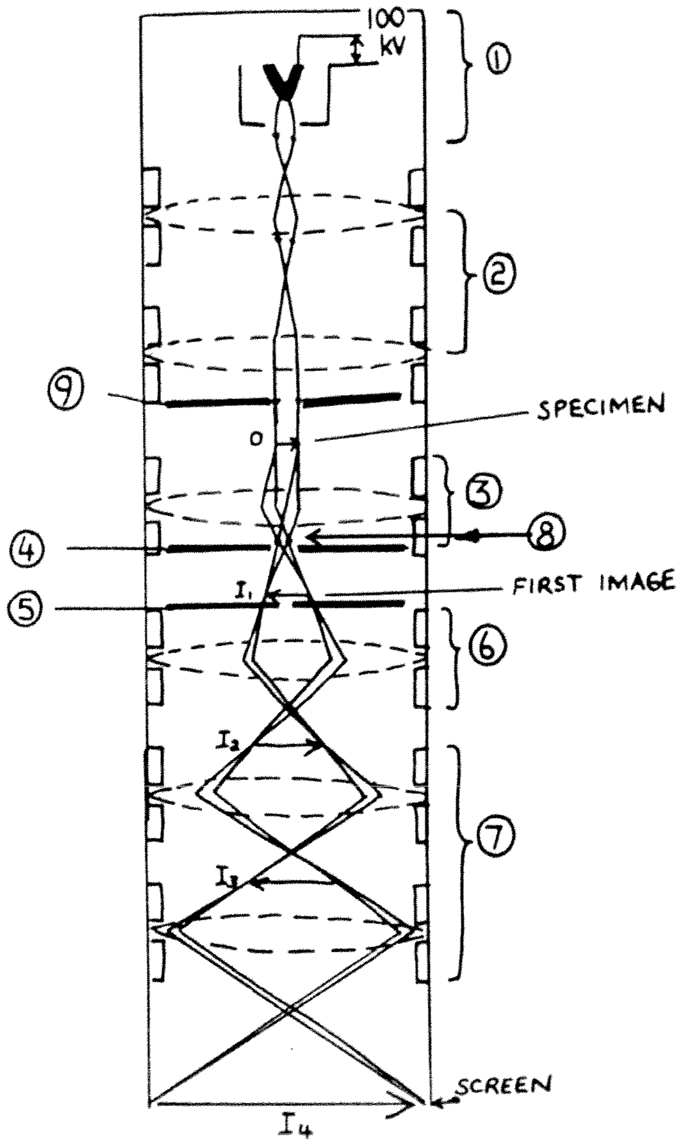


Fig.2