INDIAN INSTITUTE OF TECHNOLOGY

Date..... FN/AN Time: 3 Hrs. Full Marks: 100

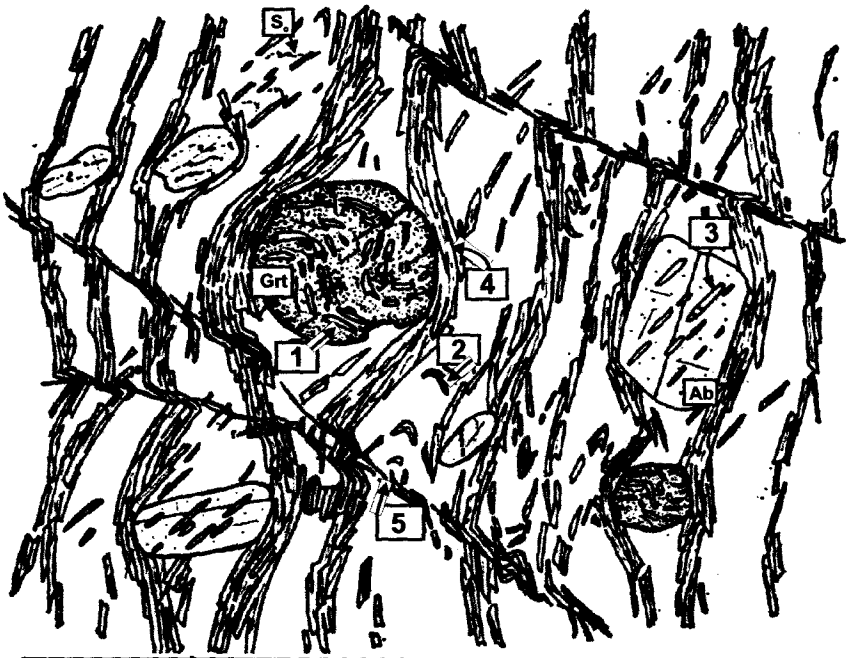
Spring End Semester, 2011 Department: Geology & Geophysics Sub No.: GG31002

Year: 3rd Sub Name: Metamorphic Petrology No. of Students: 13

Instructions: Answer Q.1 from Group A and 3 other questions (as per choice) from Group B

Group A

(1) (a) Shown below is a thin section sketch of a pelitic schist containing garnet (Grt) and albite (Ab) porphyroblasts. The pelitic schist records development of different generations of schistosity ($S_1/S_2/S_3$ etc), which is shown by the preferential alignments of flaky minerals. Relics of bedding (S_o) is shown on the top left of the diagram. Now analyse the diagram carefully and citing proper reasons, identify the generations of schistosity ($S_1/S_2/S_3$ etc) in positions 1, 2, 3, 4 and 5. Also constrain the timing of the two porphyroblast growths in relation to the schistosity development. **(5x2+2x2=14)**



(b) Shown above are three reaction textures in granulite facies metapelites, involving orthopyroxene (Opx : $(Mg,Fe)_2Si_2O_6$), sillimanite (Sill), cordierite (Cd: $(Mg,Fe)_2Al_4Si_5O_{18}$), sapphirine (Sa: $(Mg,Fe)O:Al_2O_3:SiO_2$= 2:2:1), spinel (Sp: $(Mg, Fe)Al_2O_4$) and quartz (Q). Describe the textures. Deduce the relevant mineral reactions with suitable justifications (e.g. supportive chemographic diagrams). Can you suggest the variance of the reactions in a suitable chemical system?

(3x1+3x2+3x1=12)

P.T.O.

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(c) Define and classify metamorphic facies series. What are paired metamorphic belts? With neat sketches, demonstrate their significance in reconstruction of palaeo-tectonic settings? **(2+3)+4+5**

'GROUP B' submitted

2. Using a suitable thermal model, discuss the key features of the metamorphic evolution of a continent -continent collisional orogen, including the nature of the metamorphic P-T path and the metamorphic field gradient in relation to instantaneous geotherm. **(15)**

Or

3. (a) What controls the restricted stability of the epidote-amphibolite facies in P-T space, only at pressures above 4 kbar. (b) Discuss the key metamorphic reactions and mineral compositional changes in plagioclase and amphibole that are expected to be observed in metamorphosed mafic igneous rocks across greenschist-epidote amphibolite, epidote amphibolite-amphibolite and greenschist-blueschist transition zones. (c) Name the mineral reaction, which constitutes the fundamental basis of classifying mafic granulite into three subtypes: low-pressure/medium-pressure and high-pressure granulites. Name also the mineralogy of the different varieties of mafic granulites. **(3+8+4)**

4. (a) Using a suitable petrogenetic grid in the system KASH, discuss the different types of melting reactions that may occur in natural rocks. (b) Which one of these reactions controls partial melting in natural pelites in the granulite facies? (c) Name the common univariant and divariant melting reactions that are likely to occur in granulite facies KFMASH metapelites. (d) Using a qualitative P-T pseudosection for a representative metapelite composition, speculate on the sequence of mineral assemblage evolution that is likely to be recorded for a clockwise metamorphic P-T path. (e) What kind of composition zoning in garnet will be produced along the prograde and retrograde segment of the metamorphic P-T path in (d)? **(5+2+8+6+4)**

Or

5. (a) Deduce a thermodynamic equation relating to the controls of P, T, fluid composition (in the binary system H_2O-CO_2) on a common volatilization/devolatilization reaction. (b) Giving suitable examples, name the different types of volatilization/de-volatilization reactions. (c) Discuss the shapes of these reactions in an isobaric, temperature-composition space. (d) Giving a suitable example, discuss internal and external fluid buffering. **(10+5+5+5)**

6. Consider a granulite facies garnet of pyrope-almandine solid solution (X_{Mg}=0.5), which is in contact with matrix biotite. For a slowly cooled thermal history (cooling rate =5 °C/Myr), what will be the minimum size of garnet that would be required to retrieve the peak T condition of 800 °C (at 8 kbar)? Assume binary diffusion in garnet (you will be required to use inter-diffusion coefficient, D(Fe-Mg)) and asymptotic cooling model. Given below are relevant values for D_o and Q(P) to calculate the inter-diffusion coefficient. **(20)**

Units: D_o in cm^2/s; Q in cal/mol at 1 bar; ΔV^+ in cm^3/mol

Fe: $D_o = 3.5(10^{-5})$; $Q = 65{,}532$; $\Delta V^+ = 5.6$

Mg: $D_o = 4.66(10^{-5})$; $Q = 60{,}760$; $\Delta V^+ = 5.3$

Or

7. (a) Deduce a general thermodynamic equation for a garnet-biotite Fe-Mg exchange thermometer. Assume ideal solid solution for garnet and biotite. (b) Discuss the different types of compositional zoning in garnet and how does it vary with metamorphic grade? (c) Based on your knowledge in (b), what kind of garnet composition will you choose to calculate peak metamorphic temperature for low- and high-grade metamorphic rocks? Give justifications for your answer. **(8+8+4)**

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submitted