Benha university
Faculty of science
Geology Dept.

10 / 1 /2017

Third Level
Special Geology
Metamorphic Petrology (337 G)
Time: Two Hours

نموذج اجابة

Examination of Metamorphic petrology (337 G) for the third level students (Special Geology), Jan. 2017.

Answer the following questions.

1- Write short notes about the followings (16 Marks)

(a) Different types of protoliths.

Six Common Types:

1. **Pelitic** (shale, mudstone)
2. **Quartzo-feldspathic** (sandstone, rhyolite, granite, chert)
3. **Calcareous** (limestone, dolomite, marls)
4. **Basic** (basalt, andesite, gabbro, diorite)
5. **Magnesian** (peridotite, serpentine)
6. **Ferruginous** (ironstone, umbers)

1. Pelitic Protoliths = Rocks enriched in clay minerals

• High Al2O3, K2O, lesser amounts Ca
• Micas favored because of Al content
• Also aluminosilicates: Al2SiO5 - sillimanite, andalusite, kyanite.

Kyanite: Highest density (smallest volume) forms at higher pressures.
Andalusite: Lowest density, largest volume, forms at low pressures.
Sillimanite: Intermediate density, volume; forms at moderate T, P.
Alumino-silicate triple point = 5.5 kb at 600oC
Wet granite solidus: Shows where anatexis occurs in sillimanite zone.
Staurolite (2*Al2O5*Fe(OH)2) = Common metamorphic mineral
Need an Al and Fe-rich protolith

2. Quartzo-feldspathic Protoliths: High SiO2, low Fe and Mg

· "Psammitic" is a general term for sandstone
· Quartz-rich sandstones with varying % feldspars ("arkose")
• Felsic igneous rocks (rhyolites, tuffs, granites)
• If protolith >50% quartz then probably a sandstone or chert.
• Gneiss: Fine-grained at low grade, coarser with increasing grade.

3. Calcareous Protoliths: High CaO, CO2

• Limestones and dolomite form MARBLES
• Impure limestones (with clay, silt) form Calc-silicates:

[tremolite, diopside, wollastonite, forsterite, epidote, et cetera]

4. Basic Protoliths: Low SiO2 moderate CaO, MgO, FeO

• Basalts, andesites, gabbros - mafic igneous rocks.

• Some shale-limestone mixtures.
• Minerals depend on grade: chlorite, actinolite, hornblende, plagioclase, epidote, garnet.

5. Magnesian Protoliths: Very low SiO2, high MgO
• Peridotites >> serpentine, magnesite.
• Serpentine (low T) >> antigorite (high T serpentine), olivine.

6. Ferruginous Protoliths: High Fe2O3
• Ironstones = Precambrian iron formations (Fe-rich cherts).

(b) Metabasites at the greenschist and amphibolite facies conditions.

Most of the metamorphic sequences contain mixture of sedimentary and igneous rocks. Comparable mineral assemblage in the greenschist and amphibolite of the metabasites to the metapelites include the following mineral zones:

1- Chlorite and biotite zone

Metabasite in this zone may preserve the original texture, but mineral assemblage is entirely metamorphic.

Ca-plagioclase will be replaced by albite, and a minerals Chl, Ep, pale green actinolite and quartz should be present. Biotite and calcite may be occur.

Both epidote and actinolite could be generated through the following reaction:

Chl + Cal □ Ep + Act + CO2-H2O fluid

2- Garnet zone

Grt appears at lower conditions than that in the in the metapelites

Garnets are typically Mg- and Ca-rich (slide 108).

Mineral assemblage of this zone include: blue-green Hbl + Grt + Ca-rich Pl. In addition, biotite, chlorite and epidote could occur. Both Pl and hornblende may occur via the following reaction:

Chl + ep + Qtz □ Hbl + An-Pl + H2O

3- Staurolite and kyanite zone

In this zone, Bt and chl are absent

Mineral assemblage include Green Hbl and Ca-rich plagioclase, and scarce of Epidote.

4- Sillimanite zone

The rock is dominated by brownish-green hornblende and Ca-plagioclase. No epidote remain in this zone

(c) Metamorphic facies of high pressure

Blueschist facies is a high-grade metamorphic facies typified by high pressures and associated with subduction. Also, name glaucophane –lawsonite facies. The rocks of related to this facies occur along the platetectonic boundaries where the pressure is maximum (8-6 Kbar, e. g. pacific orogenic belt and along Himalaya and Alps). These rocks are rare in the Arabo Nubian shield.

The metabasalt of the ophiolitic complexes represents good representative of this facies.

Glaucophane + Lawsonite ± Phengite, Omphacite	Meta Basic Rocks
Quartz + Jadite + Lawsonite ± Phengite, Galucophane	Metagrewackes
Aragonite)	Calcereous Rocks
Phengite + Paragonite + Quartz	Meta Pellitic Rocks

(d) Major mineralogical changes in the transition from greenschist to amphibolite facies.

Greenschist to amphibolite facies transition involves 2 major mineralogical changes
1. Transition from albite to oligoclase (increased Ca-content of stable plagioclase with T)
2. Transition from actinolite to hornblende (amphibole becomes able to accept increasing amounts of aluminum and alkalis at higher T)

2- Choose the best answers, complete, match and answer the following short question? (32 Marks)

1.	**a) chlorite b) Muscovite c) Biotite**
2.	**d) Schist.**
3.	**c) chlorite and muscovite**
4.	False, metamorphic grade refers to the relative temperature conditions under which rocks were metamorphosed
5.	**c) contact metamorphic aureole**
6.	**b) hornfels**
7.	Low pressure
8.	High temperature
9.	**e) zeolite**
10.	**a) eclogite**
11.	**contact** metamorphism
12.a	**a. What minerals would be stable at temperatures around 400oC, 600oC and 710oC?** at 400o C chlorite, muscovite, and biotite would be stable at 600o C quartz, feldspar, muscovite, biotite, garnet, and staurolite would be stable at 710o C quartz, feldspar, biotite, sillimanite, and possibly muscovite would be stable
12.b	b. If a mudstone undergoes metamorphism under wet conditions at temperatures above ~700oC, then what will happen? **It will melt**
13.	• Subduction zones Zeolite, blueschist, ecologite facies • Orogenic belts: Zeolite, prehnite-pumpellyite, greenschist, amphibolite, and granulite facies • Contact Aureoles of Intrusions in the upper crust Ab-Ep hornfels, hornblende hornfels, pyroxene hornfels and sandinite facies.
14.	**e) all of the above**
15.	**Based on this diagram, in which facies can melting begin and under what conditions** The transition from amphibolite to granulite facies occurs in the range 650-700oC In presence of aqueous fluid, associated pelitic and quartzo-feldspathic rocks (including granitoids) begin to melt in this range at low to medium pressures , so that migmatites may form and melts may become mobilized
16.	**Garnet and ompacite**
17.	**a) Gneiss.**
18.	**c) Vertical and perpendicular to stress.**
19.	e) **Shale, slate, phyllite, schist, gneiss, partial melting**.
20.	**c) As pressure and temperature change, unstable minerals react to form minerals that are stable under the new conditions.**
21.	**c) Slaty cleavage, schistosity, gneissic foliation**

22.	**b) Chlorite, muscovite, biotite, garnet, staurolite, sillimanite.**
23.	**Protolith** — **Metamorphic rock** a) Basalt. — 1. Amphibolite. b) Conglomerate. — 4. Metaconglomerate c) Dolostone. — 3. Marble d) Limestone. — 3. Marble e) Granite. — 2. Gneiss f) Sandstone. — 5. Quartzite g) Shale — 6. Slate
24.	**c) Feldspar.**
25.	**c) Hydrothermal activity..**
26.	**a) Convergent plate boundaries.**
27.	**c) the solid state.**
28.	**b) next to large bodies of intrusive igneous rocks.**
29.	**b) under conditions of high temperature and pressure.**
30.	**c) foliation.**
31.	**e) deep in a folded mountain belt.**
32.	**c) limestone - schist**

-With My Best Wishes-

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