MIGMATITES & THEIR ORIGIN

PAPER- METAMORPHIC PETROLOGY

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- **Definition:**

- **Sederholm (1908) introduced the term migmatite to designate certain gneissic rocks "which look like mixed rocks".**
- **Coarse grained, heterogeneous and megascopically composite rocks, comprising portions of granitic material (quartz + feldspar) called leucosome, and dark coloured portions of the metamorphic rocks containing mafic minerals, e.g., biotite, garnet, sillimanite, cordierite etc., which is called melanosome.**
- **lit-par-lit gneiss, composite gneiss, injection gneiss etc.**

- **Field relations and Occurrence:**

- **Migmatites are associated with metamorphic rocks of the highest temperature part of the amphibolite facies and granulite facies.**

- **“One of the most firmly established facts in metamorphic geology is the close association in field of highest grade metamorphic rocks and migmatites” Read (1957)**
- **This worldwide observation suggests that the spatial association of these rocks is due to processes occurring at similar temperature and pressure conditions in the deeper part of the crust and giving rise to high-grade metamorphic rocks and migmatites.**
- **The origin of migmatites in deep seated parts of orogenic belts must be considered as directly connected with high-grade metamorphism.**

Origin of migmatites in light of experimental work:

- **Shales and greywackes are common sediments deposited in a geosyncline.**

- **The metamorphism of these sediments was experimentally investigated by Winkler and his coworkers.**
- **The experimental anatexis of quartz-albite-K-feldspar (granite) system was investigated by Tuttle and Bowen(1958) and their data are plotted in Fig.1. The results of the experiment are summarized below:**
- **The high grade metamorphic pelitic rocks of the upper amphibolite facies contain biotite-sillimanite-garnet bearing association. These rocks remain unchanged within a certain temperature interval.**
- **When the temperature of metamorphism, however, reaches a certain value, anatexis sets in, i.e., the gneiss is partially melted in presence of water.**
- **The resulting melt is predominantly composed of quartz, plagioclase and alkali feldspars.**

- **Garnet, sillimanite, biotite and some quartz remain undissolved and form the crystalline residue**
- **Experimental anatexis of the gneiss (containing quartz + plagioclase + cordierite + K-feldspar) is shown in the ternary diagram of quartz – orthoclase – albite.**
- **Fig. 1: A melt of granitic composition is formed at temperature of 685^{o}C at E_4 having 30% melt. At this temperature, the total amount of K-feldspar melts along with eutectic amounts of plagioclase (albite) and quartz. The amount of melt formed is about 30%. With further rise in temperature, the composition of anatectic melt follows the cotectic line plagioclase-quartz until the point B is reached. The melt at point B (740^{o}C) contains mainly plagioclase and quartz and the composition corresponds to granodiorite**

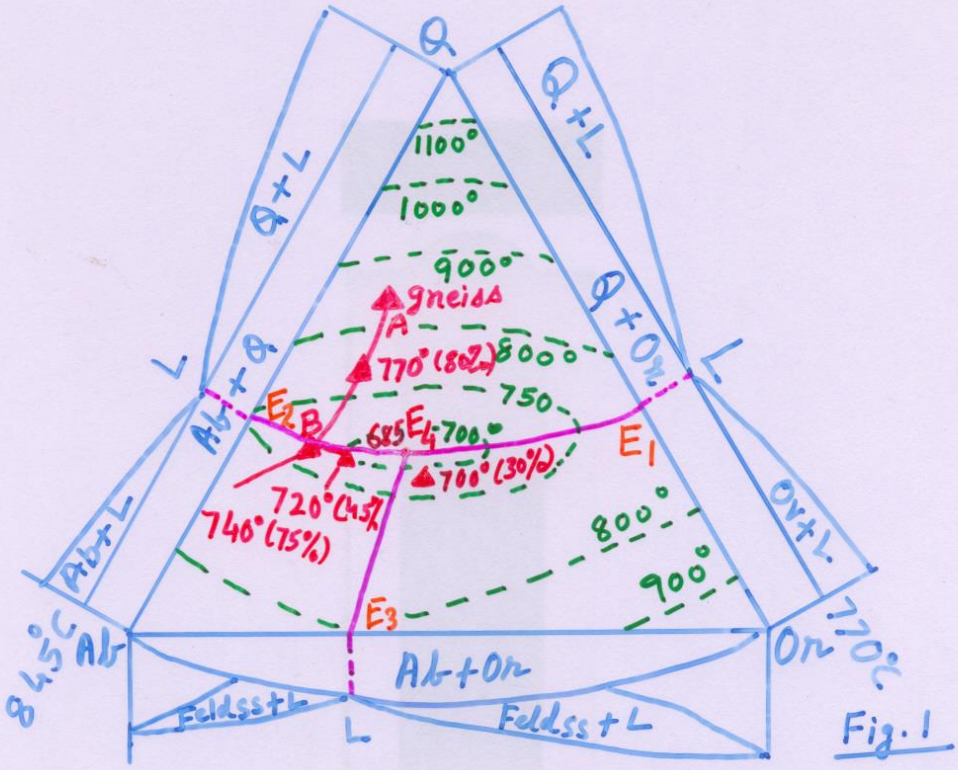

Fig. 1

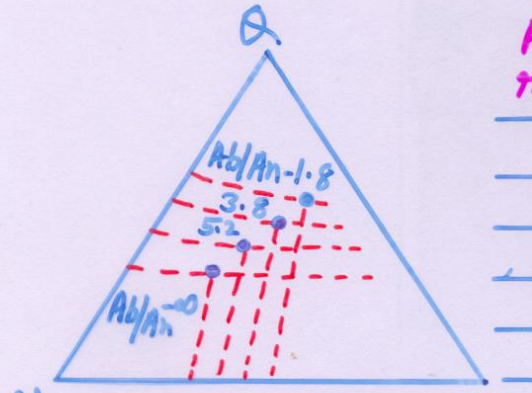

Fig. 2

Table I

Ab/An ratio	Eutectic T°C	Ratio of eutectic Comp Q	Ab	Or
∞	670	34	40	26
7.8	675	40	38	22
5.2	685	41	30	29
3.8	695	43	21	36
1.8	705	45	15	40

At 2000 bars

- **With further rise in temperature the composition of the melt moves from B to A and only quartz is present in the melt. With increase of T amount of melt produced increases following different paths ultimately to A where only quartz is present in the melt**
- **The amount of melt formed increases with increasing temperatures, e.g., at 720^{o}C it is 45%, at 740^{o}C it is 75% and at 770^{o}C it is 80%.**
- **A considerably higher temperature is required to melt all the quartz, and therefore, it is present in the residue.**
- **An- content of the plagioclase not considered by the experimental data plotted in Fig.1.**
- **The An-content has considerable effect on anatexis. Since plagioclase of the upper amphibolites facies are oligoclase or andesine, it is essential to consider its effects on anatexis.**

- **Winkler and his coworkers investigated experimentally the system Or-Ab-Qtz-An-H_2O, and have demonstrated that the eutectic composition at constant pressure depends markedly on the Ab/An ratio of plagioclase present in the gneiss.**

Conclusions:

- **The experimental results discussed above demonstrate that anatexis plays a very important role in the formation of migmatites. The P-T conditions of upper amphibolite and the granulite facies are such that anatexis would take place during regional metamorphism. The melt formed is of granitic composition which initially segregates as lenses and veins and thus separates on a scale of few centimeters to tens of centimeters from the crystalline residue. Furthermore, at a given temperature some layers will remain solid (called palaeosome), whereas others will**

contain various amounts of melt depending upon initial variation in Ab/An ratio.

- The crystalline residue will be richer in Mg, Fe, Ca, Al etc. and the melt would contain higher contents of K_2O, Na_2O and SiO_2. The overall composition of the migmatite with leucosome and melanosome remains unchanged. Such migmatites are called veinites.

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