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The study of garnet formation in the migmatite rocks, Hamadan area

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Key words: Garnet, Almandine, Garnet formation, migmatite, Hamedan.

Abstract

The study area is located in the south-southeast of Hamedan in the Sanandaj-Sirjan zone that comprising low to high grade regional (orogenic) and thermal (contact) metamorphic rocks. Intruded by mafic, intermediate and felsic plutonic bodies. Hamadan metamorphic rocks can be divided in three groups: regional metamorphic, contact metamorphic and migmatites. migmatites division in two groups: silimanite migmatite and cordirite migmatite. Garnet crystals are common pyralespite (almandine) type and this mineral recognize in leucosome, melanosome and mesosome parts. Garnet crystals in the leucosome of migmatites have igneous and metamorphic origin. In the first case, the garnet crystals was euhedral, sustainable in leucosome of migmatites and are not transformation from around to other minerals. These garnets crystallize of melt from partial melting and have igneous origin. In the second case, the garnet crystals was subhedral to anhedraland are not stable in leucosome of migmatites. These garnets are transformation and reaction from around to other minerals. These crystals have metamorphic origin and possibly remnants of mesosome garnet that residue in melt from partial melting and not melting. According to the reaction garnet formed between 550-650℃ temepture.

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Introduction

Migmatite is a rock that is a mixture of metamorphic rock and igneous rock. It is created when a metamorphic rock such as gneisspartially melts, and then that melt recrystallizes into an igneous rock, creating a mixture of the unmelted metamorphic part with the recrystallized igneous part. They can also be known as diatexite.

Migmatites form under extreme temperature conditions during prograde metamorphism, where partial melting occurs in pre-existing rocks. Migmatites are not crystallized from a totally molten material, and are not generally the result of solid-state reactions. Commonly, migmatites occur within extremely deformed rocks that represent the base of eroded mountain chains, typically within Precambriancratonic blocks. Migmatites often appear as tightly, incoherently folded (ptygmatic folds) dikelets, veins and segregations of light-colored graniticcomposition called leucosome, within dark-colored amphibole and biotite rich material called the melanosome. If present, the mesosome, intermediate in color between a leucosome and melanosome, is mostly a more or less unmodified remnant of the original parent rock (protolith). The light-colored material has the appearance of having been mobilized or molten.

Garnet crystallizes are in cubic system and mostly in dodecahedron (rhomb-dodecahedron) and trapezohedron (tetragon-trioctahedron) forms. General chemical formula of this mineral is: $R_3R'_2(SiO_4)_3$, which bivaliantcations (i.e. Mg^{2+}, Fe^{2+}, Mn^{2+}, Ca^{2+}) lie in R site and trivaliantcations (i.e. Al^{3+}, Cr^{3+}, Fe^{3+}) in R' site. Commonly, more than one cation lies in R and R' sites and therefore garnet crystals give rise to isomorphous (solid solution) series of minerals. If Al^{3+} is located in R' site, the pyralspite group $[(Fe^{2+},Mg^{2+},Mn^{2+})_3 Al_2(SiO_4)_3]$ with almandine $[(Fe^{2+})_3 Al_2(SiO_4)_3]$, pyrope $[(Mg^{2+})_3Al_2 (SiO_4)_3]$ and spessartine $[(Mn^{2+})_3Al_2(SiO_4)_3]$ end members will form. If Ca^{2+} is located in R site, the ugrandite group $[(Ca^{2+})_3(Al^{3+},Fe^{3+},Cr^{3+})_2(SiO_4)_3]$ with grossularite $[Ca_3Al_2(SiO_4)_3]$, andradite $[Ca_3(Fe^{3+})_2 (SiO_4)_3]$ and uvarovite $[Ca_3(Cr^{3+})_2(SiO_4)_3]$ end members will form. Some other cations may also be emplaced in R and R' sites (Locock, 2008). Garnet generation in the study area is highly enriched in almandine.

Porphyroblasts have representatives in every crystal system from lowest symmetry (triclinic: kyanite) to highest (isometric: garnet), and occur in metamorphic rocks representing a wide range of protolith bulk composition (e.g., basalt, shale, and carbonate) and metamorphic pressure–temperature conditions. The composition, texture, and distribution of porphyroblasts in a rock volume may also yield information about crystallization mechanisms (Kretz 1973; Prior 1987; Vernon 1988; Carlson and Denison 1992; Kretz 1993; Carlson*et al.* 1995; Daniel and Spear 1998, 1999; Meth and Carlson 1995; Wilbur and Ague 2006), rate of crystal growth (Vance and O'Nions 1990; Burton and O'Nions1991), strain rate during syn-kinematic garnet growth (Christensen *et al.* 1989; Biermeier and Stu¨we 2003), and the relationship of metamorphic crystallization and deformation(e.g., Passchier *et al.* 1992; Busa and Gray 1992;Johnson *et al.* 2006; Kruhl *et al.* 2007). In metamorphic rocks, garnet has proven very useful in tracking pressure–temperature change in a number of different ways. Garnet is central to partitioning-based geothermometry and geobarometry (Ferry and Spear, 1978; Newton and Haselton, 1981; Hoisch, 1991).

The aim of this study is, present results and demonstrate that garnet polycrystals are common in migmatite rocks; we use these results to discuss the origin of polycrystals in these rocks.

Materials and methods

The area under study

The study area is a part of the Sanandaj-Sirjan metamorphic belt that comprising regional metamorphism (low to high grade) and thermal (contact) metamorphism.

This are placed between Longitude 48°51’6” to 48°45’29” N and latitude are 34°32’9.3” to 34°51’35.5” E (Fig 1).

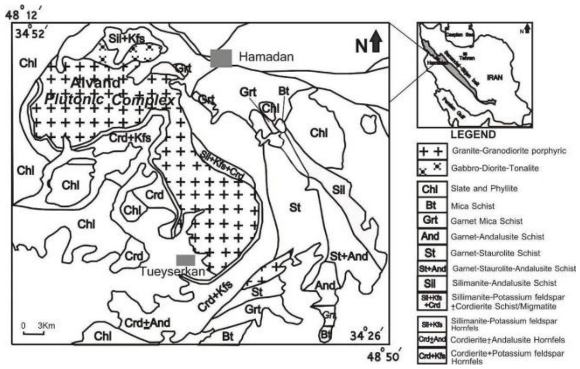

Fig. 1. Petrology map of Hamadan area.

Research Method

To Petrography studies and study the morphology of crystals of garnet in metamorphic and igneous rocks, after field studies and systematic sampling, the samples studied thin sections were prepared. After studying petrography, whole rock samples and garnet crystals in laboratories Kanpajoh Tehran .The garnet crystals found in the samples analyzed using Electron Microprobe appropriate JEOL 8900 geology and Geophysics University of Minnesota in the United States, the accelerating voltage and current kV15 nA25 were investigated.

To determine the morphology of crystals of garnet, after conducting field investigations, the crystals in the laboratory by periodically changing the angle of the light microscope and the crystals were studied. The results of chemical analysis by EPMA analyze point to garnet with the formula to calculate the percentage of the final structure is given in Tables 1.

Table 1. The results of EPMA analyses of garnet crystals in migmatite rocks.

	Sim-L Leucosome Migmatite		Sim-M2 Melanosome Migmatite	
	Core	Rim	Core	Rim
SiO2	35.96	36.10	35.80	37.27
TiO2	0.00	0.00	0.10	0.00
Al2O3	21.70	21.57	21.27	21.89
FeO	29.97	34.23	29.53	35.97
MnO	10.13	3.65	8.70	2.64
MgO	1.59	2.66	1.48	2.26
CaO	1.09	1.01	2.93	1.88
Total	100.44	99.22	99.80	101.91
Cations	12 ox.	12 ox.	12 ox.	12 ox.
Si	2.93	2.95	2.93	2.96
Ti	0.00	0.00	0.00	0.00
Al	2.08	2.07	2.05	2.05
Fe	2.04	2.33	2.02	2.39
Mn	0.70	0.25	0.60	0.18
Mg	0.19	0.32	0.18	0.27
Ca	0.10	0.09	0.26	0.16
X-Alm	0.67	0.78	0.66	0.80
X-Sps	0.23	0.08	0.20	0.06
X-Prp	0.06	0.11	0.06	0.09
X-Grs	0.03	0.03	0.08	0.05

Result and discussion

We can divide Hamadan metamorphic rocks in three groups: regional metamorphic rocks, contact metamorphic rocks and migmatites. Metamorphic rocks are mostly composed of slates, phyllites, schists, migmatites and hornfelses.

These crystals are usually common in all of the metamorphic rocks (unless slate and phyllite). Migmatite rocks located in the Simin valley in the south Hamadan area, in the Longitude 48°32'39"N and latitude is 34°39'27"E. migmatite rocks formation is in the crust with partial melting. If the liquid cannot escape the environment and remain in the same place these rocks are formed (Brown, 1994).

We consider four probabilities to form Migmatite: Two probability are including material enters from exogenous to rock (magma injection and metasomatism). Metamorphism and partial melting are differentiation possibilities that include the source of leucosome of the rocks. Migmatites in the hand samples are dark gray, sometimes brown and have a heterogeneous construct and felsic streaks or lenses are in the dark field (fig 2). In the thin section migmatites have minerals such as quartz, muscovite, chlorite, biotite, plagioclase, garnet, Staurolite, Sillimanite, Cordierite, sometimes Potassium feldspar and tourmaline.

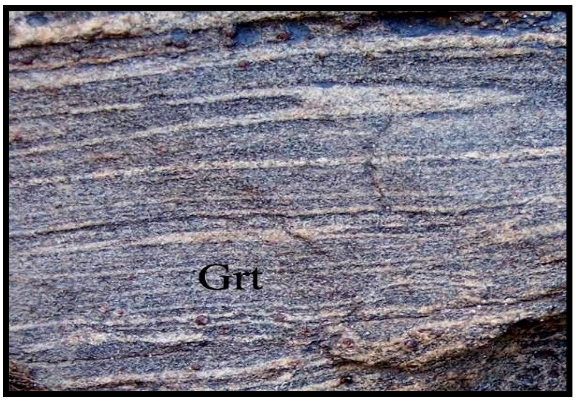

Fig. 2. Migmatite rocks, garnet crystalls are showing in the locosome and melanosome.

Due to the abundance of minerals we can divide migmatites in two groups: sillimanite migmatite and Cordierite migmatite. Existing garnets in migmatites are mainly among the pyralspite groups (especially those rich in almandine) and theses porphyroblast size is more than 1 cm (Table 1).

Garnet cryastals seen in the leucosome, mesosome and melanosome of migmatites but it originated in this parts are different. Garnet crystals in the leucosome of migmatites have igneous and metamorphic origin.

1. In the first case, the garnet crystals was euhedral, sustainable in leucosome of migmatitesand are not transformation from around to other minerals. These garnets crystallize of melt from partial melting and have igneous origin. The leucosome part consists of minerals such as more of quartz, plagioclase, orthoclase, biotite and sometimes muscovite and has idioblastic texture (Fig 3).

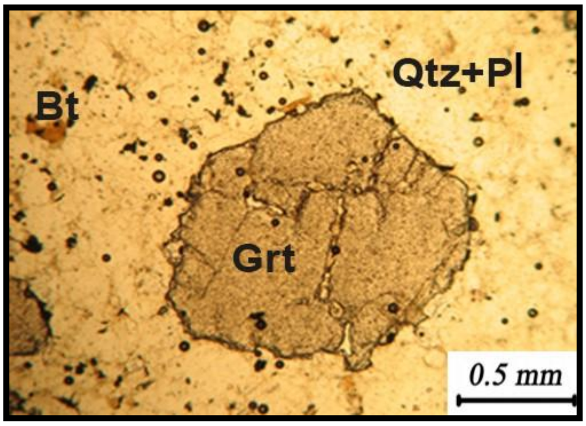

Fig. 3. Photomicrograph showing subhedral garnet in leucosome of migmatites with metamorphic origin.

2. In the second case, the garnet crystals was subhedral to anhedraland are not stable in leucosome of migmatites. These garnets are transformation and reaction from around to other minerals. These crystals have metamorphic origin and possibly remnants of mesosome garnet that residue in melt from partial melting and not melting (Fig 4).

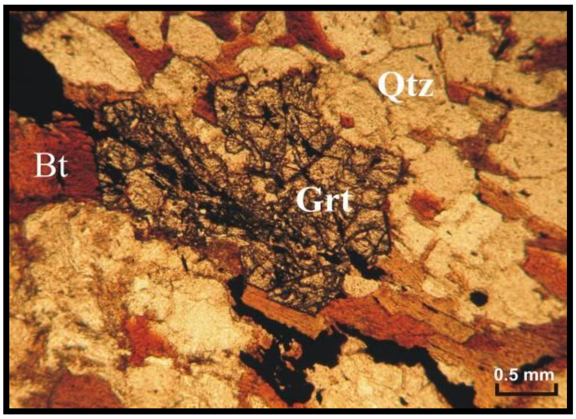

Fig. 4. Photomicrograph showing euhedral garnet in the melanosome part in migmatites.

Due to conversion schists and hornfelses to migmatites, garnet crystals in the mesosome and melanosome have metamorphic origin. Reactions of garnet formation in these rocks spend Biotite and as follows:

1. Bt + Sil + Qtz → Grt + Kfs + H2O (Tracy, 1982) According to this reaction garnet formed between 550-650° temepture.

2. Bt + Ab + Sil + Qtz → Grt + Kfs + L (Norlander *et al*, 2002)

The melanosome part consists minerals such as quartz, chlorite, muscovite, biotite and consists porphiroblast such as sillimanite, Cordierite and sometimes tourmaline. This part has lepidoblastic texture.

Separation between mesosome and melanosome part are difficult. But parts that rich in biotite, garnet or staurolite and depletion quartz and plagioclase can be considered mesosome. Garnets in mesosome part are more frequency than other part.

Conclusions

Existing garnets in migmatites are mainly among the pyralspite groups (especially those rich in almandine) and theses porphyroblast size is more than 1 cm. Garnet cryastalsbe seen in the leucosome, mesosome and melanosome of migmatites but it originated in this parts are different. Garnet crystals in the leucosome of migmatites have igneous and metamorphic origin. 1. In the first case, the garnet crystals was euhedral, sustainable in leucosome of migmatitesand are not transformation from around to other minerals. These garnets crystallize of melt from partial melting and have igneous origin. 2. In the second case, the garnet crystals was subhedral to anhedraland are not stable in leucosome of migmatites. These garnets are transformation and reaction from around to other minerals. These crystals have metamorphic origin and possibly remnants of mesosome garnet that residue in melt from partial melting and not melting. According to the reaction garnet formed between 550-650 ℃ temperature.

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