The assemblage garnet-clinopyroxene-plagioclase-quartz in products of melting from the Central Rhodope

Асоциацията гранат-клинопироксен-плагиоклаз-кварц в продукти на топене от Централни Родопи

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The assemblage of coexisting garnet, clinopyroxene, plagioclase and quartz occur in retrogressed HT eclogites, as well as in upper amphibolite facies metabasic rocks, or in HP granulite facies basic and intermediate metamorphic rocks that often bear record of partial melting (Hartel, Pattison, 1996; O'Brian, Rötzler, 2003; Pattison, 2003). The reaction that accounts for the prograde development of garnet-clinopyroxene-plagioclase-quartz from a hornblende-plagioclase-quartz-bearing precursor is Hbl+Pl+Qtz = Grt+Cpx+melt (abbreviations after Siivola, Schmid, 2007). Partial fusion experiments with amphibolites (Springer, Seck, 1997) produce garnet-clinopyroxene dominated residual and trondhjemitic to dioritic melts. Compositional factors of bulk rock in the range of Mg/(Mg+Fe) 0.35–0.65 favouring their development at upper amphibolite grade include Ca-rich garnet (Grs_{40}) and plagioclase (An_{50}), whereas HP granulite conditions correspond with Ca decrease both in garnet and plagioclase (Grs_{15}; An_{20}; Pattison, 2003).

In the Rhodopes' metamorphic rocks coexisting garnet, clinopyroxene, plagioclase, quartz, and amphibole are common in retrogressed eclogites from the higher-grade metamorphic units (Kolcheva et al., 1986; Liati, Seidel, 1996, and reference therein). The same orthopyroxene-free assemblage is typical of coarse-grained garnet amphibolites of the Arda unit in the Chepelare area (Chepelare mélange). They associate with garnet-kyanite gneisses, whose peak metamorphic assemblage is indicative for HP granulite facies metamorphism and dehydratation melting in the kyanite stability field (Georgieva et al., 2007). Recently, coexisting garnet, clinopyroxene, plagioclase and quartz are found in massive to weakly foliated felsic rock fragments in old prospecting trenches from the Mechi chal area together with ordinary migmatitic garnet-kyanite gneisses and schists.

Samples description and mineral chemistry

Unevengrained quartz-feldspar matrix envelopes 1–4 mm euhedral garnets and subhedral to ovoid clinopyroxene grains. Garnet cores contain single and polyphase inclusions of quartz, plagioclase, K-feldspar, amphibole, sphene, and rutile. The inclusion assemblage in clinopyroxene comprises plagioclase, amphibole and quartz. The matrix is composed of medium-grained quartz aggregates, anhedral plagioclase, and anastomosing microgrannular plagioclase dominated quartz-feldspar aggregates. Single grains and clusters of subhedral titanite associate with garnet rims. In foliated samples secondary amphibole and biotite occure along clinopyroxene and garnet rims respectively, rarely accompanied by chlorite.

Garnets grains have almandine-grossulare compositions in the range $Alm_{56-70}Grs_{27-40}Prp_{18-28}Sps_{2-5}$. Profiles of inclusions-bearing garnet cores towards inclusions free zone suggest prograde growth documented by increasing Mg and decreasing Fe and Mn in samples of massive texture. Commonly garnet grains do not display well defined zonation in foliated samples. Clinopyroxene compositions are diopside dominated with higher Al and Na contents in the core (Al_2O_3 3.02–8.43%; Na_2O 0.94–1.73%) and lower contents in large grains rims and smaller grains in the matrix. The most common plagioclase is of andesine composition in the range An_{35}–Am_{40} that refers to plagioclase inclusions in garnet and clinopyroxene, and to matrix plagioclase grains as well. Incomplete plagioclase reequilibration during retrogression is marked by local compositional variation and exolutions ($An_{<30}$ and $An_{>60}$) in plagioclase along retrogressive rims containing amphibole, biotite, and chlorite, as well as in amphibole-bearing poliphase inclusions in garnet and clinopyroxene. Amphibole inclusions display inhomogeneous compositions of magnesiohornblende and tschermakite. The appearance of orthoclase rich K-feldspar ($Or_{>90}$) both in the polyphase inclusions and in the felsic matrix most probably refers to subsolidus reequilibration of high-tepmerature plagioclase. Biotite is rich in Ti and Mg (TiO_2 3.23–4.39%; Fe/(Fe+Mg) 0.25–0.41), suggesting high-temperature retrogression.

Interpretation

We consider quartz-feldspar matrix crystallized melt, and inclusions trapped during peritectic garnet and clinopyroxene growth. The microstructural relations between inclusions and poikilitic garnet and clinopyroxene grains suggest pro-grade melting reactions, namely: Hbl+Pl+Qtz = Grt+Cpx+melt (Pattison, 2003); or Hbl+Pl+Qtz = Grt+Cpx+Ttn+melt (Hartel, Pattison, 1996). Ductile deformation favoured subsolidus fluid assisted retrogression at high-grade conditions.

Observed reequilibration of amphibole-plagioclase inclusions does not allow rigorous determination of the melting reaction P-T conditions The subassemblage of garnet, clinopyroxene and plagioclase represents reactions products. The equilibrium between garnet and clinopyroxene cores and quartz-plagioclase inclusions is supposed to record conditions of melt crystallization. Different calibrations of garnet-clinopyroxene-plagioclase thermobarometry yield similar results in the range 710–780° C/1.1–1.5 GPa that indicate transitional PT conditions between upper amphibolite and HP granulite facies.

The results correspond to thermobarometric estimates available on HT/HP melting in the Chepelare area (Cherneva, Georgieva, 2007; Cherneva et al., 2008; Georgieva, 2007). Similar P-T values characterize the Arda unit eclogites retrogression through granulite facies (Carrigan et al., 2006). Missing information on field relations of the samples studied preclude correct correlation with melting precursor. Nevertheless, the data focuse attention on the process of melting of mafic and intermediate amphibole-bearing metamorphic rocks at high pressure conditions.

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