Products of HP melting in Chepelare shear zone, Central Rhodope, Bulgaria – petrology, P-T estimates and U-Th-Pb dating

Продукти на високобарично топене от Чепеларска зона на срязване, Централни Родопи, България – петрология, P-T условия и U-Th-Pb датиране

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Key words: zircon, monazite, La-ICP-MS, pelites, garnet-bearing anatectic melts, Chepelare, Rhodope.

Introduction

Two distinct partial melting events have been documented recently by in situ monazite dating in garnet-kyanite schists in the Chepelare shear zone, Central Rhodope (Bosse et al., 2010). The late-Jurassic metamorphic event (137–142 Ma) is connected with granulite facies metamorphism and is recorded also in the metabasic rocks from the Chepelare metamorphic pile (Georgieva et al., 2010). The Cenozoic fluid-assisted melting event (38–42 Ma) is related to amphibolite facies overprint and is widespread in the adjacent orthogneisses. We present new data on petrology, conditions and time of formation of garnet-bearing para-autohtonous anatectic melts, which spatially associate with garnet-kyanite schists in the same area.

Petrology and mineral chemistry

Two samples collected along the road to the marble quarry eastward of the town of Chepelare represent migmatites in close relations with Grt-Ky gneiss. The first sample (HP-50) is leucocratic gneiss with leucosome segregation 3–5 cm thick and gneissic part with large garnets enveloped by biotite. The second sample (HP-40) is garnet-bearing biotite gneiss with banded diffuse kyanite-bearing leucosome.

The leucosome in the leucocratic gneiss is composed of fine-grained matrix and resorbed large grains (up to 1cm) of plagioclase and K-feldspar, some of them with antiperthitic and perthitic exolutions. Together with quartz ribbons they are roughly orientated along the foliation. The fine-grained matrix is composed of plagioclase (An_{12-18}) mainly with some quartz, K-feldspar (Or_{88-91}) and muscovite. The minerals have planar boundaries, isometric shapes and form triple junctions. Muscovite forms the foliation and is dominantly concentrated at borders of feldspar grains and quartz ribbons. The gneissic part is garnet-bearing, with lower proportion of large feldspar grains and biotite present in the matrix. Garnet grains (1–5 mm) are disintegrated and replaced by biotite (XFe 58–70). The later is often pseudomorphosed by K-feldspar (Or_{96-98}) or chlorite in association with muscovite. Scarce inclusions in garnets are presented by single biotite grains (XFe 44–56) or polymineral assemblage of albite (An_1), K-feldspar (Or_{98}), muscovite and biotite. Garnet fragments are almandine rich and display complex zoning, which is difficult to interpret as core to rim change in elements distribution. Central parts show higher Pyr and Grs contents and XMg (Alm_{72-78} Pyr_{11-15} Grs_{8-11} Sps_{1-2} XMg_{14-16}), than the retrograde rim (Alm_{80-85} Pyr_{6-12} Grs_{2-8} Sps_{3-5} XMg_{7-11}). But in many grains, the central parts have domains with higher and lower XMg and dramatic change in Grs content. Accessory minerals are apatite, rare titanite and rutile, often replaced by ilmenite. Numerous small rounded zircons and some bigger euhedral grains occur together with monazite in quartz ribbons mainly, as well as in big feldspars, in finegrained matrix, and close to resorbed garnet rims.

The garnet-bearing biotite gneiss (HP-40) has similar petrographic features like the leucocratic one. Garnets are smaller, without inclusions and completely replaced by biotite commonly. The later is more abundant in the matrix and with lower Fe content (XFe 48–53), than in previous sample. Big K-feldspar grains have perthitic exolutions (An_{17-19}) and enriched in Na central parts (core-rim Or_{78}–Or_{83}). Antiperthites in big plagioclase grains (An_{14-18}) have the same com-position as matrix K-feldspar ($Or_{85–87}$). Plagioclase ($An_{14–18}$) is the most abundant matrix mineral together with biotite. Matrix K-feldspar has higher modal proportion than in the leucocratic gneiss. Garnet grains display clearer zoning with flat or weakly prograde cores and retrograde rims (core→rim Alm 53→58, Pyr 20→14, Grs 21→8, Sps 5→18). The Grs, Pyr and Sps contents are higher than in sample HP-50. Abundant accessory zircon and monazite have similar microstructural position.

We consider large grains feldspar grains as relicts, affected by deformation and resorbtion during formation and recrystallization of the finegrained matrix. The complex garnet zoning in the leucocratic gneiss suggests mixed relict – perithectic origin. The element distribution in the garnets from the biotite gneiss could be explained with crystallization during a melt-producing reaction. Garnets with similar high Grs content, associated with low-An plagioclase are described as products of HP melting (Cherneva et al., 2008). Biotite formation after garnet (melt back reaction probably) is followed by chlorite, K-feldspar and muscovite replacement that marks final fluid-present retrogression.

P-T conditions

We used garnet-biotite exchange (Holdaway, 2000) for temperature and garnet-plagioclase-biotite-quartz association (Hoisch, 1990) for pressure estimations based on garnet rims associated with matrix plagioclase and retrograde biotite. The leucocratic gneiss yield temperatures values between 650 and 700 °C at 0.7–1.1 GPa. In biotite gneiss estimated temperatures and pressures are higher (750–800 °C at 1.6–1.8 GPa) and close to previously reported by Cherneva et al. (2008). These P-T conditions refer to one retrograde path and depend on intensity of the back-reaction.

Geochronology

U-Th-Pb analyses of zircons and monazites were carried out in thin sections and mineral separates by LA-CP-MS at Geological Institute, Bulgarian Academy of Sciences, and at Laboratory of Magmas and Volcanoes, Clermont-Ferrand, France. The monazite ages in both samples cluster together in the range 137–144 Ma with younger ages at grains rims (120–130 Ma). Similar monazite ages have been reported for garnet-kyanite schist (Bosse et al., 2010). Two groups of zircon grains were analysed in the leucocratic gneiss (HP-50). Euhedral grains with sector zoning or lack of zoning on CL images yield ages in the range of 120–140 Ma with higher probability at 128–134 Ma. The second group is fragments or euhedral grains with clear zoning on CL images – dark cores surrounded by brighter rims. Most of the ages are discordant. For the inner zones they range from 140 to 250 Ma, the brighter rims are at 126–136 Ma. The same two types of zircons have been studied also in the biotite gneiss (HP-40). The zircons with sector zoning yield ages between 119–139 Ma with higher probability at 129–134 Ma. In the second group, the grains show on CL images clear zoning with very bright or dark cores and several zones to the rim. Outermost rims have similar ages as zircons with sector zoning (120–140 Ma). On probability density plot the data for the inner zones spread from 250–270 up to 320 Ma. These preliminarily results suppose new formation for the first group of zircons and monazites and disturbed Hercynian protolith ages for the second group of the zircons.

Discussion

The new data give evidences for the presence of garnet-bearing para-autohtonous anatectic melts in spatial association with garnet-kyanite schists. The geochronological data confirm previous results for Mesozoic age of HP granulite facies metamorphic event. Petrological and P-T estimates overlap partly those for garnet-bearing HP anatectic melts with metaluminous precursor form the Mechi Chal area (Cherneva et al., 2008), and give new insights on melt formation and crystallization in pelitic system.

Acknowledgements: This study was supported by National Science Fund – Bulgaria, project DO02-363/2008 and RNF 01/0006.

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