Garnet-clinopyroxene-K-feldspar granulites from Chepelare shear zone, Central Rhodope massif, Bulgaria – petrology and mineral chemistry

Гранат-клинопироксен-К-фелдшпатови гранулити от Чепеларската зона на срязване, Централни Родопи, България – петрология и химизъм на минералите

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Introduction and geological setting

The variegated rock assemblage known as Chepelare Formation, Chepelare mélange or Chepelare shear zone, coincides with approximately 1 km-thick zone of intense strain, previously interpreted as a synmetamorphic thrust of presumed Mesozoic age. However, recent data indicate that this strain was still active during the Late Eocene (Gerdjikov et al., 2010). The Chepelare shear zone is squeezed between the migmatic gneisses of the Arda lithotectonic unit (Sarov et al., 2010), and consists of garnet-bearing metabasites, pure and impure marbles, garnet-kyanite gneisses and schists, biotite or two-mica gneisses, small ultramific bodies and eclogite boudins. High-pressure granulite facies mineral assemblages and P-T estimates for different rock types from the zone (Cherneva et al., 2008; Georgieva et al., 2007, 2010) were interpreted as late overprint, probably after UHP metamorphism (Coolings et al., 2011), during the Late Jurassic time.

Petrography and mineral chemistry

Mesocratic carbonate-free rocks with big garnet porphyroblasts (up to 1.5 cm) crop out in the Marble quarry, east of the town of Chepelare. There are no good root outcrops and relationships with other rock types, but the big blocks and abundant small samples suggest the presence of thick (1–2 m) level or boudin in the southern part of the quarry. The rocks have three distinct parts: mesocratic homogeneous matrix of clinopyroxene-K-feldspar-plagioclase-quartz with clear foliation; bands and lenses of big garnet porphyroblasts intergrowth with K-feldspar and clinopyroxene ± late amphibole; and strongly foliated fine-grained bands of chloritized biotite and white mica, oriented at small angle towards the foliation, and banded along the porphyroblasts. These distinct in composition and grain size parts suggest a consecutive formation at changing P-T and fluid regime conditions.

Garnet porphyroblasts appear often as aggregates of small hypidioblastic grains intergrown with clinopyroxene, K-feldspar and late amphibole. Bigger garnet grains have tails of K-feldspar, quartz, amphibole and inclusions of K-feldspar, epidote and pyrite. Garnets are almandine-grossular dominated with high variation of all compounds: $Alm_{38–62}$, $Grs_{22–48}$, $Pyr_{4–10}$ and $Sps_{5–13}$. Profiles in bigger garnet grains do not display clear core to rim zonation, it is weakly prograde or almost flat. When larger garnets pass into clusters of small hypidioblastic grains an abrupt change in composition is observed: $Alm_{60\to47}$, $Grs_{22\to44}$, $Pyr_{6\to4}$, $Sps_{12\to5}$, and $XMg_{10\to8}$. This high variation in garnet composition is controlled by grossular content and suggests two garnet generations. *Clinopyroxene* associates with garnet porphyroblasts where it forms big grains (up to 1 cm), and also with the more homogeneous mesocratic matrix, as hypidioblastic grains, elongated to the foliation. In both cases the pyroxene is diopside, with XMg from 52 to 60. Diopside porphyroblasts are replaced along the cleavage planes or almost entirely by amphibole. *K-feldspars* form big, xenomorphic grains, which intergrow with garnet and clinopyroxene, and contains inclusions of epidote, allanite and opaque minerals. Close to garnet porphyroblasts smaller, weekly deformed K-feldspars, with triple junctions contact with few strongly myrmekitized plagioclases. The K-feldspar is also present in the mesocratic matrix, where its grains are smaller and elongated and with myrmekitized plagioclase at contacts. Ab content in K-feldspar is up to 12.5 mol.% (average 5 mol.%). *Plagioclase* (labrador-bitovnite, $An_{65–78}$) is more abundant in the mesocratic matrix. The plagioclases (oligoclase-andesines, An_{19-46}) associated with big garnet, clinopyroxene and K-feldspar, are scarce and strongly myrmekitized. In both cases, the orthoclase compound is low (up to Or_2). *Amphibole* was formed after clinopyroxene, from the coarse-grained parts, is present also as monomineral bands and aggregates and includes garnet, plagioclase and quartz. Hornblende is calcic, with XMg from 35 to 51, and it is classified mainly as ferropargasite (less as pargasite, edenite and ferroedenite). Zoned grains show rising MgO (6.9 to 8.7 wt.%) and Al^{VI} (0.52 to 0.68 *apfu*) from the core to the rim.

The accessory minerals are titanite, allanite, zircon, apatite, pyrite, and opaque minerals. Biotite, chlorite and margarite are present in strongly deformed fine-grained bands. The latter include minerals from the matrix and coarse-grained parts, which are deformed and with reduced grain size.

The peak mineral assemblage of porphyroblastic garnet, clinopyroxene and K-feldspar forms beyond the plagioclase stability field. The expense of plagioclase in prograde metamorphic reactions could explain the extreme variation in plagioclase composition, formation of grossular enriched garnet and high XAb in K-feldspar. We assume that peak mineral assemblage forms after clinopyroxene-plagioclase-K-feldspar-quartz mesocratic matrix, which is rich in Ca, Al and K. Amphibole is late and replaces clinopyroxene. Biotite-chlorite-margarite deformed bands are the lattermost and mark the final deformation at active fluid regime.

Thermobarometry

At 1 GPa garnet-clinopyroxene thermometer (Krough Ravna, 2000) yields temperatures of 740 °C for small garnet ($Alm_{41.8}$, $Grs_{44.1}$, $Pyr_{7.3}$, $Sps_{6.8}$, $XMg_{14.9}$) included in clinopyroxene core (XMg_{59}) and 810 °C for garnet ($Alm_{41.8}$, $Grs_{44.5}$, $Pyr_{6.6}$, $Sps_{7.2}$, $XMg_{13.6}$) partly included in clinopyroxene rim (XMg_{62}). These data suggest equilibrium crystallization at prograde conditions and although no pressure estimates are available, the temperatures obtained are similar to the previously reported for the Chepelare shear zone rocks and correspond to granilute facies metamorphism.

Conclusions

The granulite facies associations with garnet-kyanite-K-feldspar for metapelites, and garnet-clinopyroxene for metabasites, are well constrained by experimental data and petrographic observations (Pattison et al., 2003). The observed mineral assemblage of garnet-clinopyroxene-K-feldspar was not reported often for granulite facies, but the petrographic observations and temperature estimates correspond to its high-pressure part. Further modeling of the mesocratic matrix and coarse-grained bands composition is needed to reconstruct the protolith geochemistry. Carbonate minerals are not present in any part of the rock, but possible reactions of dehydratation and decarbonation could clarify the mechanism of rock formation and constrained the fluid regime during the metamorphism.

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References

Cherneva, Z., I. Gerdjikov, P. Gautier, V. Bosse, M. Georgieva. 2008. The assemblage garnet-clinopyroxene-plagioclase-quartz in products of melting from the Central Rhodope. – In: *Proceedings of National conference "Geosciences 2008"*. Sofia, BGS, 39–40.

Coolings, D., I. Savov, J. Harvey. 2011. First report of micro-diamond in kyanite-garnet schist and coesite in eclogite from the Central Rhodope massif, Bulgaria. – In: *AGU Fall Meeting*. San Francisco. V23E–2606.

Georgieva, M., Z. Cherneva, A. Mogessie, E. Stancheva. 2007. Garnet-kyanite schists from the Chepelare area, Central Rhodope Mts., Bulgaria: mineral chemistry, thermobarometry and indications for high-pressure melting. – In: *Proceedings of National conference "Geosciences 2007"*. Sofia, BGS, 97–98.

Georgieva, M., Z. Cherneva, I. Gerdjikov, E. Stancheva. 2010. Metabasic rocks from the Chepelare variegated complex, Central Rhodope massif, Bulgaria – preliminary studies. – In: *Abstracts volume of the XIX Congress CBGA*. Thessaloniki, Greece, Sep. 23–26, 2010. *Geologica Balc.*, *39*, 1–2, 131–132.

Gerdjikov, I., P. Gautier, Z. Cherneva, V. Bosse, G. Ruffet. 2010. Late Eocene synmetamorphic thrusting and syn-orogenic extension across the metamorphic pile of the Bulgarian Central Rhodope. – In: *Abstracts volume of the XIX Congress CBGA*. Thessaloniki, Greece, Sep. 23–26, 2010. *Geologica Balc.*, *39*, 1–2, 132–133.

Krough Ravna, E. 2000. The garnet-clinopyroxene Fe^{2+}-Mg geothermometer: an updated calibration. – *J. Metam. Geol.*, *18*, 211–219.

Pattison, D., T. Chacko, J. Farquhar, C. McFarlane. 2003. Temperatures of granulite-facies metamorphism: constraints from experimental phase equilibria and thermobarometry corrected for retrograde exchange. – *J. Petrol.*, *44*, 867–900.

Sarov, S., E. Voinova, M. Ovtcharova, K. Naydenov, N. Georgiev, D. Dimov. 2010. Lithotectonic subdivision of the metamorphic rocks in Rila-Rhodope region. – In: *Proceedings of National conference "Geosciences 2010"*. Sofia, BGS, p. 121.