Eclogites from Arda tectonic unit – mineralogy and evidence for short-leaved granulite facies overprint

Еклогити от Арденската тектонска единица – минералогия и доказателства за кратковременен гранулитов метаморфизъм

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Introduction

The modern geological studies in the Rhodopes added new information about the syn- and postmetamorphic deformations, on one hand (Ivanov, 1998, Tectonics of Bulgaria, unpublished; Burg et al., 1996), and about the age of the protoliths of the metamorphic rocks and the time of their metamorphism, on the other. The idea for Paleozoic (mostly Hercynian) age of the protoliths, and Alpine age of the regional metamorphism and the related deformations, became popular (Burg et al., 1996; Ivanov, 1998, unpublished). In the general tectonic plan the Rhodope massif is considered as a metamorphic-core complex (Burg et al., 1996).

Most of the rocks have been affected by high-pressure metamorphic events, succeeded by metamorphism of the high temperature – low pressure type ending with low temperature – low pressure changes. Intensive anatexis proceeded in the deepest parts of the section. A few announcements for ultra high-pressure metamorphism of the rocks from the Rhodope massif were reported during the last few years.

The goal of the study is a detailed investigation of the metaeclogites from the lower parts of Arda tectonic unit (Kosharite place near the town of Ardino) and determination of the P-T conditions of their formation.

Petrology

Arda unit (Ivanov, 1998, unpublished) is part of the Central Rhodope metamorphic group – high grade ortho-and para-metamorphites, affected by intensive migmatization and anatexis. The eclogites are enclosed in biotite or two-mica gneisses (metagranites) and occur as boudinated isolate bodies (Kolcheva et al., 1986). The high-pressure (HP) mineral assemblage is presented by garnet (Grt)+omphacite (Omph)+kyanite (Ky)+rutile (Rt).

Garnet occurs as big porphyroblasts up to 0.5 cm with inclusions of Qtz, Ru, Ky and Omph. They have typical progressive zoning (Ca, Mn and Fe content decrease from core to rim and Mg increases in same direction) with retrograde zoning in the thin rim area.

Omphacite is preserved as single grains only in garnet. In the matrix it is partly or totally replaced by Pl-Cpx_1 symplectites. The Jd content varies in narrow range – 26.15–33.60 %.

Kyanite is observed as rounded relict grains replaced by zoned corona of microsymplectite. Many grains are completely replaced.

Rutile occurs as numerous small grains included in garnet porphyroblasts or in symplectitized matrix.

The next assemblages were formed by decreasing pressure and still high to very high temperature. Under dry conditions the HP mineral assemblage was destabilized but incompletely re-equilibrated. Omphacite breaks down to Pl+Cpx_1 symplectites. They are strongly zoned – the size of the mineral grains decreases from relict Omph crystal to the rim of the symplectitic corona. The plagioclase is $An_{15–20}$ and the pyroxene has lower Jd component (8–22%). As a rule the bigger Cpx_1 from the symplectites have higher Jd content than the small ones.

Simultaneously with Pl+Cpx_1 symplectite formation, the kyanite-omphacite breakdown causes the appearance of high-temperature assemblage Spr+Spl+Pl($An_{44–54}$)+Cpx_2+Ilm+Pl($An_{24–36}$). Probably the pyroxene from the symplectites takes part in these HT reactions, too. This HT assemblage allows assuming the appearance of corundum also, as reported from the eclogites from the Greek part of Arda unit (Liati, Seidel, 1996). The new Cpx_2 is a poor diopside (0–8.9% Jd) and is observed only in the destroyed rim areas of Grt in association with Pl ($An_{24–36}$) and Ilm.

During the earlier high-temperature amphibolite facies overprint of the eclogites in the presence of water, a new stable mineral as Amph+Pl+Bt was

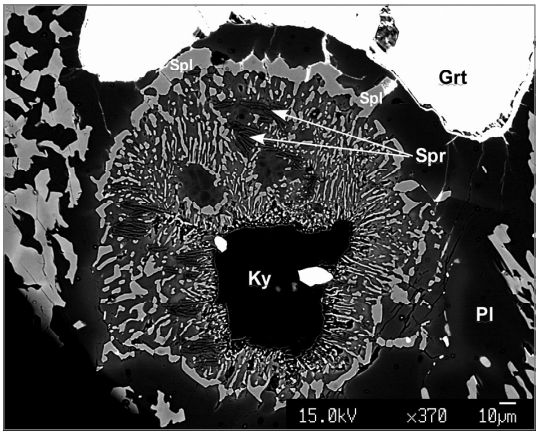

Fig. 1. Spinel (Spl)–sapphirine (Spr)–plagioclase (Pl) corona around kyanite (Ky) porphyroblast in the eclogites from Arda unit

formed under relatively static conditions. Amphibole (pargasite) forms symplectites with plagioclase or coronas around garnet porphyroblasts. Immediately to the contact with garnet the amphibole is significantly enrich in aluminum. Biotite is Mg rich (X_{Mg}=0.77–0.81) and is observed as small isolated sub- to euhedral grains, but never with a direct contact with amphibole, or as symplectites with plagioclase. Usually Bt-Pl symplectites are reported from overprinted eclogites as a breakdown product of phengite (Franz et al., 1986). In both cases the plagioclase has a composition of $An_{18–25}$. Rutile is rarely replaced by ilmenite or titanite.

Conclusion

The determined equilibrium mineral assemblages in the metaeclogites from the lower part of Arda unit, which reflect different stages of evolution provide a very good opportunity to reconstruct P-T conditions of their elapse. The temperature of the HP metamorphism was defined by Zr in rutile thermometer of Watson et al. (2006) and is in the range 730–769° C (780° C and 20 kb estimated by Kolcheva et al., 1986). The Jd in pyroxene barometer provide pressure conditions at about 20–22 kbar. After the pressure peak of metamorphism for a short time the eclogites were put to anomalous high to ultrahigh temperature (granulite facies) and the assemblage Spr+Spl+Cpx+Ilm+Pl($An_{24–36}$; $An_{44–54}$) was produced whereas the garnet preserves its prograde zoning and rutile composition was not equilibrated. For the Spl-Spr-Pl symplectite formation Carrigan et al. (2002) estimate a temperature up to 800° C at 14.5 kb. The Spl-Spr equilibrium thermometers estimate a temperature range 850–880° C.

Using Hbl-Pl thermometer of Blundy, Holland (1990) we obtain 655–711° C temperature interval for the final amphibolite facies metamorphism at 8 kb (Al_t in Hb barometer). The Al-rich amphibole from garnet coronas determines a higher temperature (679–736° C and 10–12 kb) i.e amphibole growth continues relatively longer time.

We must conclude that the studied eclogites were rapidly heated as well as rapidly cooled down. Such thermal spikes are inconsistent with commonly presented P-T paths and strongly imply that the granulite facies metamorphism was not due to simple thermal relaxation, but to a short leaved thermal pulse. This feature is characteristic for the eclogites in the European Variscides (O'Brien, Vrana, 1995).

The investigated eclogites together with Pl-Spl coronas around kyanite in the metapelites from the Western slope of Pirin Mountain. (this volume), gedrite-anthophyllite association in the semipelites from Kesebir dome, Cpx-Opx-Pl assemblage in eclogites from Sredna Gora Mnt. (unpublished data of the authors) give a strong evidence, that the HT (granulite facies) overprint of high-grade metamorphic rocks from South Bulgaria is a widespread phenomenon.

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