Back-arc basin metabasites from the Krumovitsa unit, Eastern Rhodope (Bulgaria)

Заддъгови метабазити от единицата Крумовица, Източни Родопи (България)

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Introduction and geological setting

Ophiolitic complexes, as remnants of oceanic crust and upper mantle, give valuable information about the evolutionary history of ancient basins and play a crucial role in reconstruction of geodynamic evolution of the orogenic belts. Emplaced within the metamorphic complexes, ophiolithic suites are useful in defining their metamorphic P-T-t path and geodynamic settings. Metabasic rocks (amphibolites and eclogites) are wide spread in the Variegated complex of the Eastern Rhodope associated with ultramafic bodies, felsic and mica gneisses, metapelites and marbles. According to the recent lithotectonic subdivision (Sarov, 2012), they belong to the Krumovitsa and Devisil units or to the Upper high-grade basement unit (Bonev et al., 2013), and are correlated with Kimi unit in the Eastern Greek Rhodope. Previous geochronological data suggested UHP event and subsequent granulite facies overprint at Mesozoic time (e.g., Bauer et al., 2007; Liati et al., 2011; Georgieva, 2014), followed by two or three younger metamorphic events at lower facies. Preserved magmatic zones of zircons showed Paleozoic to Neoproterozoic crystallization of metabasics protoliths (e.g., Bauer et al., 2007; Bonev et al., 2013). The available geochemical data for metabasics from the Bulgarian part are partly incomplete, but point to a suprasubduction zone (SSZ) settings and boninitic affinity (Haydoutov et al., 2003; Bonev et al., 2013).

Analytical methods and samples description

We studied 11 amphibolites and 3 eclogite samples from the area of Egrek, Avren, Malak and Goliam Devisil and Devsilovo villages in central and south part of the Krumovitsa and Devisil units. Major elements in whole-rock samples were determined at the Geochemical Laboratory (Sofia University) via wet silicate analyses. Trace elements were determined by LA-ICP-MS at the Geological Institute (BAS), using whole rocks' SiO_2 content as internal standards and NIST 610 as external standard. Mineral chemistry was studied by JEOL-733 electron microprobe, at the Geological Institute (BAS), at 15 kV for 100 s, using natural and synthetic standards.

Main minerals in amphibolies are tschermatic amphibole, plagioclase ($An_{15–18}$), epidote, quartz ± garnet, rarely biotite. The accessory minerals assemblage includes titanite, rutile, ilmenite, pyrite and apatite. The amphibolites are medium to coarse grained and display good foliation. In the most of the samples, the features of retrograde reactions, with formation of minor calcite, epidote, chlorite and scapolite are visible in thin sections. Late cross-cutting veins, filled with quartz and epidote, mark the final extension. The retrogressed eclogites are massive, with fine-grained matrix and garnet porphyroblasts. The high-pressure mineral assemblage in eclogites is not preserved. Relict garnet porphyroblasts (almandine-pyrope) and augite to sodic augite ($Jd_{6–17}$) are the main minerals. Late amphibole and plagioclase form reaction structures along garnet and augite boundaries. The abundant rutile is replaced by opaque minerals. Applied suitable geothermobarometers for both, amphibolites and eclogites, point to intense amphibolite facies (650–700 °C at 0.65–1.25 GPa), overprinting higher metamorphic events.

Geochemistry

The concept of immobile element geochemistry is applied in study of ancient and metamorphosed ophiolite complexes (Pearce, 2014 and review therein). In the same time, the growing amount of tectonic discrimination diagrams, some of them with overlapping fields, could lead to contradictory results. On commonly used discrimination diagrams based on main and trace elements our samples plot mainly within the MORB field. Pearce (2014) proposed modified diagrams for classification and discrimination of the MORB vs SSZ related rocks. According to the immobile elements plot Nb/Y-Zr/Ti for classification of igneous rocks (after Pearce, 2014), the studied samples as basalts. On the Th/Yb versus Nb/Yb diagram the data disperse from the MORB-OIB array to higher Th/Yb ratio within oceanic arcs field (Pearce, 2014). The variable and high Th/Yb ratio is typical for subduction related rocks. To clarify further the samples with SSZ origin Pearce (2014) proposed modified Ti-V plot of Shervais (1982). The studied samples correspond to MORB and slab-distal BABB (back-arc basin basalt) and FAB (forearc basalt). The chondrite normalized REE patterns are flat or show weak LREE enrichment (La_N/Lu_N from 0.8 to 3, average 1.7) and lack or weak negative Eu anomaly. On multielement N-MORB normalized patterns our samples are enriched in mobile elements (Cs, Th, La, Ce, and Pb) and show pronounced negative Nb and Ta anomaly typical for subduction related rocks. Having in mind that the studied samples are metamorphosed, the mobile elements enrichment could be partly related to the interaction with crustal materials during metamorphism.

Geochemically the amphibolites and eclogites are indistinguishable, suggesting a common protoliths and different metamorphic history. The samples from Krumovitsa and Devisil units show similar geochemical features and should be regarded as part of one ophiolite complex. In the studied part of the Krumovitsa unit we do not record rocks with boninitic affinity (e.g., Haydoutov et al., 2003). Based on immobile element geochemistry, the studied metabasites are very close to the MORB, with weak crustal input, which implies a formation at back-arc basin setting.

The present new and complete geochemical data on amphibolites and eclogites from the Krumovitsa unit will improve our knowledge for the ophiolithic rocks and the geodynamic evolution of the Eastern Rhodope region. Our results have a good correlation with the geochemical data, reported by Baziotis et al. (2008) for retrogressed eclogites from the Kimi unit, Greek Rhodope.

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