Protoliths and metamorphic events in the high-grade metamorphic basement of the Eastern Rhodope: constraints from U-Pb zircon geochronology

Протолити и метаморфни събития във високостепенния метаморфен фундамент на Източните Родопи: ограничения от U-Pb цирконова геохронология

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Introduction

The depositional age of the protoliths in the high-grade metamorphic basement of the Rhodope was traditionally considered as Pre-Cambrian (including both the Arhaean and the Proterozoic – Kozhoukharov, 1987). Recent U-Pb zircon geochronology data have revealed protoliths in the high-grade metamorphic basement and metamorphic ages spanning distinct time intervals of the Paleozoic and the Mesozoic. It becomes evident that the lower unit (i.e. the Eastern Rhodope, togheter with the middle/intermediate unit for the Central Rhodope) of the high-grade basement consists mostly of Carboniferous granitoid protoliths (Liati et al., 2011 and references therein), while the upper unit (Eastern Rhodope) of the high-grade basement in addition to Carboniferous protoliths also includes Ordovician, Permian–Triassic and Jurassic magmatic protoliths (Liati et al., 2011; Bonev et al., 2013, 2015). The overlying unit of the Circum-Rhodope Belt (Eastern Rhodope) consists of Middle Triassic–Jurassic sedimentary rocks (Meinhold et al., 2010) and Middle Jurassic arc-related ophiolites (Bonev et al., 2015). This contribution presents and discusses additional U-Pb zircon age constraint on the protoliths and timing of the metamorphic events in the high-grade basement of the Eastern Rhodope region.

Geological setting

In the Eastern Rhodope, southwest of the village of Avren in Southern Bulgaria, the para- and orthometamorphic sequence of the upper high-grade basement unit hosts a large number of meta-peridotite bodies and lenses. The largest meta-peridotite body composed mainly of altered harzburgite and dunite called Avren I body (Kolcheva et al., 2000) occurs in lithologic contacts with underlying schists, gneisses and amphibolites and overlain by marbles. At the contacts of the Avren I body the surrounding rocks locally demonstrate ductile deformation. At the eastern contact of the Avren I body, structurally below the marbles, the field observations have demonstrated a thin discontinuous amphibolite layer that rims the meta-peridotite body against the marbles. The amphibolite consits of medium to coarse-grained plagioclase feldspar and amphibole dominated rock that resembles meta-gabbroic precursor.

Results

In thin section the amphibolite displays main phases of plagioclase and amphibole. Igneous grain sizes and shapes of the euhedral lamellar plagioclase are well-preserved, while the elongated amphibole that defines the foliation has metamorphic origin. Epidote and sphene are minor phases, and rare rutile, zircon and apatite are the most frequent accesories. Major- and trace elements composition of the amphibolite reveals low-Ti and low-K protolith, and together with the petrography and trace elements normalized patterns of the amphibolite, demonstrates MORB-depleted gabbroic precursor.

Zircons from the amphibolite were separated by standard density and magnetic techniques and were imaged in cathodeluminescence mode by a microprobe in the University of Belgrade, Serbia. The zircons show oscillatory and sector-zoned prismatic crystals that are characteristic for magmatic origin. Two zircon grains display light thin outer rims of metamorphic or-

igin and one zircon posseses an inherited core. Eight zircons were dated by LA-ICP-MS in the Geological Institute of the Bulgarian Academy of Sciences. The analyses yielded a range of $^{206}Pb/^{238}U$ ages between 850 Ma and 32 Ma. Single ages of 850 Ma, 573 Ma, 502 Ma, 389 Ma and 249 Ma with Th/U in the range 1.13–0.33 yielded the magmatic core domains of dated zircons, while the ages of 360 Ma (Th/U=0.01) and 75 Ma (Th/U=0.04) yielded respectively the outer zone and the rim of metamorphic origin in two zircons. A single zircon age of 32 Ma results from an analysis in inherited core with few inclusions, and thus resulting from the disturbance of the U/Pb isotopic system.

Discussion

Inherited zircons with Cambrian ages occur in the meta-plagiogranite of Ordovician protolith age (Bonev et al., 2013) and Neoproterozoic magmatic zircons yielded a meta-gabbro (Carrigan et al., 2003), and all these dates comes from the same metamorphic unit of the Eastern Rhodope. Inherited Neoproterozoic–Cambrian, Ordovician and Carboniferous zircons were also found in the lavas of Oligocene paleovolcano Iran tepe and Oligocene alkaline basalt dyke that are respectively adjacent or within the same unit (Bonev et al., 2013). The zircons dated as Middle Devonian–Carboniferous may well witnesses for the Variscan magmatic and metamorphic history. All these Neoproterozoic–Carboniferous ages suggests an inheritance of the zircons sampled from the metamorphic basement by the magmatic precursor of the studied amphibolite. In turn, the nicely oscillatory zoned zircon with an age of 249 Ma suggests that it might well date the magmatic history of the amphibolite protolith. In this sense the amphibolite has magmatic precursor derived from the Late Permian–Triassic rifting magmatic history known at the continental margin of Eurasia within the north Aegean region. Rift stage magmatic products are not unusual in the region because the Upper Jurassic granitoids sampled 277–260 Ma-old inherited zircons (Bonev et al., 2015) and the protolith zircon ages between 245 Ma and 255 Ma reported in meta-gabbros of the same unit were also related to the Permian–Triassic rifting (Liati et al., 2011). The age of 75 Ma in the amphibolite is close to the zircon metamorphic age of 74–71 Ma (Liati et al., 2011) of the amphibolite facies metamorphism that continued to ca. 65 Ma (Bonev et al., 2015).

This study further opens the question about the composition, timing and location of the Permian–Triassic rifting stage magmatic products and associated sedimentary rocks in the Rhodope zone within the tectonic framework of the northern Aegean region. The Rhodope zone urgently needs to be linked in a proper way to the continental break-up and Early Mesozoic tectonic development at the continental margin of Eurasia.

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