Middle Triassic magmatic crystallization of the Volvi metamafic body, Serbo-Macedonian Massif, Northern Greece: new evidence for Triassic rifting history

Магматична кристализация през Средния Триас на метамафичното тяло Волви, Сърбо-Македонски масив, Северна Гърция: нови данни за триаска рифтова история

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Introduction

The crystallization age of the metamafic protoliths in the high-grade metamorphic basement of the Serbo-Macedonian massif in Northern Greece still remains controversial issue despite the relatively large extent of the metaultramafic-metamafic bodies (Kockel et al., 1977) that built the Therma-Volvi-Gomati (TVG) complex (Dixon, Dimitriadis, 1984). Recent U-Pb zircon geochronology (three spots) revealed an age of 252±13 Ma for the gabbroic protolith of the Volvi metamafic body (Liati et al., 2011), whose magmatic crystallization visibly straddles the Paleozoic–Mesozoic boundary. The TVG complex was proposed as the location of the Paleotethys Ocean suture zone in the western termination of the Cimmerides in the Balkan region (Şengör et al., 1984) based on field and geochemical data of Dixon and Dimitriadis (1984) who, however, consider this complex as *in situ* Mesozoic intra-continental rift. Nevertheless, the TVG complex is still considered a suture zone under the name Athos-Volvi zone despite documented nearby A-type anorogenic rift-related Triassic Arnea granite suite (mean U-Pb age of 228 Ma, Himmerkus et al., 2009). The follow-up whole-rock and Sr-Nd-Pb isotope geochemistry confirmed the rift signature of the Therma and Volvi bodies and has also revealed equivalent metamafic rocks in the Western Rhodope Massif of Bulgaria (Bonev, Dilek, 2010; Bonev et al., 2012). This contribution documents and discusses new U-Pb zircon age constraint on the magmatic crystallization of gabbroic protolith in the Volvi metamafic body.

Geological setting and field data

In the Serbo-Macedonian Massif, the para- and orthometamorphic sequence of the high-grade basement is traditionally subdivided into a lower Kerdilion unit and an upper Vertiskos unit separated by ductile thrust (Burg et al., 1995) or an extensional detachment fault (e.g. Kydonakis et al., 2016). High-pressure metamorphism followed by medium-pressure amphibolite event at ca. 132 Ma which event cooled between 125–100 Ma characterizes the Vertiskos unit, and these low-temperature ages are consistent with the K-Ar age of 116–111 Ma obtained for the Volvi body (e.g. Kydonakis et al., 2016). The Volvi body composed mainly of gabbro and rare basalt occurs in lithologic contacts with the schists and gneisses of the Vertiskos unit lying close to the boundary with the Kerdilion unit. In the field, the Volvi gabbro is intruded by the Arnea granitoids. At the contacts, the Volvi body demonstrates ductile deformation similarly to the surrounding Vertiskos rocks, where the gabbro is turned into massive and banded amphibolite. The internal parts of the Volvi body preserve variably textured coarse- to fine-grained and pegmatoid weakly deformed gabbro. The primary clinopyroxene and plagioclase are well-preserved in the gabbro, but most often the clinopyroxene is surrounded by macroscopic amphibole of metamorphic origin. In severely metamorphosed and deformed gabbro the amphibole is the dominant mafic mineral, occasionally complemented by biotite in gabbro-diorite varieties. Very coarse-grained plagioclase, clinopyroxene and amphibole dominated pegmatoid

metagabbro from the internal part of the Volvi body was selected for U-Pb geochronology analysis.

Results

In thin section the pegmatoid gabbro mainly consists of plagioclase and clinopyroxene. Igneous grain sizes and shapes of the plagioclase are very well-preserved, while the clinopyroxene is replaced by metamorphic amphibole. Minor phases are Fe-Ti oxides, garnet, epidote, sphene and accesories include zircon and apatite. Zircons from the pegmatoid metagabbro sample were separated by standard density and magnetic techniques and were imaged in cathodeluminescence mode using SEM at the University of Belgrade, Serbia. The prismatic zircon crystals show well-developed sector and oscillatory zonation, indicative of magmatic origin. Most of the zircons posseses thin bright outer rims of metamorphic origin. Twenty four zircons were dated by LA-ICP-MS at the Geological Institute of the Bulgarian Academy of Sciences. Three zircon crystals yielded discordant U-Pb ages between 295 Ma and 215 Ma. The analyses in 21 zircons yielded a concordant age of 240.2±1.8 Ma (MSWD 0.016, probability 0.90), with Th/U in the range 0.79–0.39, that is typical for magmatic zircons. Thus, we interpret the obtained U-Pb age to date the magmatic crystallization of the protolith of pegmatoid metagabbro from the Volvi metamafic body.

Discussion

The new U-Pb LA-ICP-MS zircon age for the magmatic crystallization of pegmatoid metagabbro protolith allows temporal link between the Volvi body and known Middle Triassic rift-related acid igneous activity recorded in the Serbo-Macedonian massif. The ages of 234 Ma and 230 Ma for the Arnea granite suite immediately south and west of the Volvi body, respectively (Himmerkus et al., 2009) further corroborates the obtained Middle Triassic rift-related age constraint for that body. Collectivelly, these age constraints define temporally close bimodal magmatic continental rift suite for which also proof exists from field data and mutual intrusive relationships, particularly west of the Volvi body. In this sense the Volvi metamafic body testifies Triassic rifting magmatic history at the continental margin of Eurasia within the North Aegean region. The link to inferred Paleotethys suture zone becomes less obvious and unrealistic because Middle Triassic ocean floor magmatism associated to Paleotethys is unknown in the area studied, and this ocean was closed by the end of Triassic as known in NW Turkey e.g. Karakaya complex.

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References

Bonev, N., Y. Dilek. 2010. Geochemistry and tectonic significance of proto-ophiolitic metamafic units from the Serbo-Macedonian and western Rhodope massifs (Bulgaria-Greece). – *Int. Geol Rev.*, *52*, 298–335.

Bonev, N., Y. Dilek, J. M. Hancar, K. Bogdanov, L. Klain. 2012. Nd-Sr-Pb isotopic composition and mantle sources of Triassic rift units in the Serbo-Macedonian and the western Rhodope massifs (Bulgaria-Greece). – *Geol. Mag.*, *149*, 1, 146–152.

Burg, J.-P., L.-E. Ricou, I. Godfriaux. 1995. Extension of the Mesozoic Rhodope thrust units in the Vertiskos-Kerdilion Massifs (northern Greece). – *C. R. Acad. Sci. Paris*, *320*, 889–896.

Dixon, J. E., S. Dimitriadis. 1984. Metamorphosed ophiolitic rocks from the Serbo-Macedonian Massif, near Lake Volvi, north-east Greece. – In: Robertson, A. H. F., J. E. Dixon (Eds.). *Tectonic Evolution of the Eastern Mediterranean*. Geol. Soc. London, Sp. Publ., 17, 603–618.

Himmerkus, F., T. Reischmann, D. Kostopoulos. 2009. Triassic rift-related meta-granites in the Internal Hellenides, Greece. – *Geol. Mag.*, *146*, 2, 252–265.

Kockel, F., H. Mollat, H. W. Walther. 1977. *Erläuterungen zur geologischen Karte der Chalkidiki und angrenzender Gebiete 1/100.000 (Nord-Griechenland)*. Hanover, Bundesanstalt für Geowissenschaften und Rohstoffe, 119 p.

Kydonakis, K., J.-P. Brun, M. Poujol, P. Monié, E. Chatziteodoridis. 2016. Inferences on the Mesozoic evolution of the North Aegean from the isotopic record of the Chalkidiki block. – *Tectonophys.*, *682*, 65–84.

Liati, A., D. Gebauer, C. M. Fanning. 2011. Geochronology of the Alpine UHP Rhodope zone: A review of isotopic ages and constraints on the geodynamic evolution. – In: Dobrzhinetskaya, L. F., S. W. Faryad, S. Wallis, S. Cuthbert (Eds.). *Ultrahigh-Pressure Metamorphism. 25 Years after the Discovery of Coesite and Diamond.* Elsevier, 295–324.

Şengör, A. M. C., Y. Yilmaz, O. Sungurlu. 1984. Tectonics of the Mediterannen Cimmerides: nature and evolution of the western termination of Palaeo-Tethys. – In: Robertson, A. H. F., J. E. Dixon (Eds.). *Tectonic Evolution of the Eastern Mediterranean*. Geol. Soc. London, Sp. Publ., 17, 77–112.