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P-T conditions and time of migmatization in the south-western part of the Rhodope metamorphic terrain (Slashten unit)

P-T условия и време на мигматизация в югозападната част на Родопския метаморфен терен (Слащенска единица)

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Introduction

The most widespread migmatites in the Rhodope metamorphic terrain resulted from fluid assisted melting during Paleocene–Eocene time (50–36 Ma). Typical representatives occur in the Central Rhodope units Arda and Madan. Similar conditions of migmatization are suggested for the Chepinska unit migmatites in the Western Rhodope, although the time of migmatization (63–59 Ma) is not precisely defined yet (Cherneva et al., 2006). Limited data are available on migmatites in the south-western part of the Rhodope metamorphic terrain. Recent studies give information of late-Jurassic migmatitic leucosome (147–165 Ma) in the Slashten unit (von Quadt et al., 2008). The same leucosome is considered as injection of granite material or periplutonic melt related to abundant late-Jurassic granite protoliths of similar age in the area (Sarov et al., 2010). Migmatite-like rocks of solid-state origin occur in the same unit according to Machev (2010). Abovementioned data and interpretations raise questions regarding migmatization in the Slashten unit and focus attention on leucosome-like leucocratic bands origin, on P-T conditions, and on the time of their formation.

We present new petrological and geochronological data to elucidate the origin of different scale leucocratic bands in biotite and amphibole-biotite gneisses from the southernmost fragment of the Slashten unit.

Field relations and samples

The Slashten lithotectonic unit consists of varied in composition para- and orthometamorphic rocks metamorphosed at amphibolite facies conditions (Sarov et al., 2008, 2010). Migmatite-like rocks have limited occurrence in the unit. The majority of so called banded migmatites are strongly affected by ductile deformation that obliterated original relations between leucocratic bands and host gneisses. The former crop out as foliation parallel felsic granite or pegmatoid injections or dismembered and boudinaged leucocratic veins of centimetric to metric scale thickness. Very few outcrops display undoubted cases of *in situ* leucosome formation. These appear as several centimeters thick patches or elongated lenses bordered by melanosome selvages enriched in amphibole and/or biotite.

The studied samples represent migmatites of two outcrops: (I) *in situ* leucosome (VB6, VB9) in amphibole-biotite orthogneiss (VB8, VB10) and metric scale leucogranite body (VB11) in the same gneisses from the Mutnitsa river valley SW of Petrelik village; (II) *in situ* leucosome (VB21) in biotite gneiss (VB20) from an outcrop to the North of check point “Ilinden” at the Bulgarian–Greece border.

Petrology

Gneisses and *in situ* leucosomes have similar rock-forming minerals assemblages that differ in mineral proportions only. The samples from the Mutnitsa river outcrop are composed of quartz, plagioclase, K-feldspar, biotite, and amphibole. The accessory minerals assemblage comprises magnetite, zircon, apatite, titanite, epidote ± allanite cores. The leucosome is quartz-feldspar dominated with subhedral amphibole grains concentrated along leucosome boundaries (VB6). Amphibole grains contain euhedral plagioclase and epidote inclusions and display straight line boundaries with some large plagioclase grains in the matrix. The leucogranite body (VB11) is amphibole-free, with minor biotite and larger proportion of K-feldspar. The samples from the second outcrop are composed of quartz, plagioclase, K-feldspar and biotite, with the same accessory mineral assemblage.

Mineral chemistry data refer to the samples of the Mutnitsa river outcrop, which textural relations indicate cases of plagioclase-amphibole equilibrium. Plagioclase compositions An_{28-32} are similar in leucosome (VB6, VB9) and gneiss sample (VB8), while leucogranite (VB11) is distinguished by more sodic plagioclase An_{13-16}. The composition of amphibole is similar in leucosome and gneiss samples (VB6 and VB8) corresponding to pargasite-ferropargasite joint (Si 6.13–6.26 apfu; #Mg 0.46–0.53).

Plagioclase-hornblende thermobarometry (Anderson, 1996 and reference therein; Ferschtater, 1990; Holland, Blundy, 1994) yields similar results for amphibole pairs with plagioclase inclusions and matrix plagioclase in the range 691–724 °C/7.4–8.6 kbar. We consider these results conditions of leucosome crystallization slightly affected by retrogression probably during postmigmatitic ductile deformation.

U-Pb dating

Zircon grains from gneiss samples (VB8, VB10, VB20) show prismatic to short-prismatic morphology and CL images of complex internal microtextures including inherited cores, wide band of oscillatory magmatic zoning combined with sector zoning in some grains, and thin outer rim marking change towards long prismatic morphology. Long-prismatic sector zoned zircon grains free of cores are common in leucosome (CB9, VB21) and leucogranite (VB11).

LA-ICP-MS analyses of selected zircons yield two groups of age results: late-Jurassic and late-Cretaceous to early-Paleogene. Weighted average $^{206}Pb/^{238}U$ ages of the first group refer to oscillatory zoned zircons from gneisses, namely: 147.5 ± 6.4 Ma (VB8); and 156.0 ± 3.3 Ma (VB20). These correspond to widespread magmatic protolith ages in the Slashten and neighbour units. The second group of ages comes from leucosome and leucogranite samples, as well as from outer rims in gneiss' zircons: 74.1 ± 3.9 Ma (VB9); 71.3 ± 5.1 Ma (VB11); 65.6 ± 5.7 Ma (VB21); and 73.2 ± 8.5 Ma (VB20). Some specific features of the latter zircons (low U and Pb contents) call for additional work to obtain more precise age results.

Conclusions

The process of migmatization in the southernmost part of the Slashten unit operated at high-grade amphibolite facies conditions and produced felsic melts that crystallized *in situ* at 691–724 °C/7.7–8.6 kbar. Similar zircon morphology and age results for leucosomes and leucogranite body give evidence for deformation assisted melt migration that could explain at least part of leucocratic injections origin. The melting event affected late Jurassic magmatic protoliths. In spite of scattered results and large error, it seems obvious that *in-situ* leucosome formation and syn-deformational melt migration happened at the end of Cretaceous or in the beginning of Paleogene time, contemporaneously with and/or predating widespread intrusive granite magmatism in the SW Rhodope metamorphic terrain.

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