Hydrous juvenile mafic lower crust due to amphibole-bearing cumulates formation beneath arc volcanoes: preliminary study from the Upper Cretaceous subvolcanic bodies near to Praveshka Lakavitsa village, Bulgaria

Водонаситена ювенилна мафична долна кора, свързана с формирането на амфиболсъдържащи кумулати под дъгови вулкани: предварителни данни от горнокредни субвулканските тела в околностите на с. Правешка Лакавица, България

Stoyan Georgiev¹, Raya Raicheva¹, Peter Marchev¹, Irena Peytcheva¹, ², Elitsa Stefanova¹

¹ Geological Institute, Bulgarian Academy of Sciences, 1113 Sofia, Bulgaria; E-mail: kantega@abv.bg
² Institute of Geochemistry and Petrology, ETH-Zurich, 8092 Zurich

Key words: juvenile mafic cumulate lower crust, U-Pb dating, Late Cretaceous magmatic activity.

Introduction

The subvolcanic bodies and dikes near to the villages of Praveshka and Osikovska Lakavitsa (to north of Botevgrad town) represents the northernmost outcrops of the Late Cretaceous magmatic activity of that segment of the Apuseni–Banat–Timok–Srednogorie magmatic belt. They form an E-W directed elongated zone intruded in the Lower Cretaceous sedimentary succession. Numerous xenoliths and mafic enclaves are observed in the intermediate subvolcanic rocks (Stoyanova, 1994 and reference therein). The present study provides new data about the geochemistry and geochronology of the magmatic rocks and the xenoliths in order to constrain better the time of magma generation and the magma evolution and sources.

Analytical methods

Major elements of bulk samples are determined using dilution ICP-AES (at Aquaterratest Lab, Sofia) and the trace elements are obtained on fused pellets using LA-ICP-MS (at GI-BAS, Sofia). In-situ U-Th-Pb age dating of the zircons is made applying the LA-ICP-MS method (GI-BAS). The major element mineral chemistry is achieved by a JEOL 870 SUPERPROBE at the University of Florence and energy-dispersive X-Max Large Area Analytical Silicon Drifted spectrometer (Oxford) coupled with a scanning electron microscope JSM-259 6610 LV at the University of Belgrade. The whole-rock $^{87}\text{Sr}/^{86}\text{Sr}$ and $^{143}\text{Nd}/^{144}\text{Nd}$ ratios are obtained after a chromatographic cleaning procedure by ID-TIMS (TritonPlus) at ETH-Zurich.

Results

The subvolcanic rocks studied are presented mostly by monzogranodiorite porphyries with fine grained groundmass and phenocrysts of plagioclase (andesine-labrador), amphibole (magnesiohastingsite), clinopyroxene (diopside) and accessories of apatite, allanite, titanite, zircon, and magnetite. Some of the amphibole phenocrysts (Fig. 1a) reveal reverse zonation with lower Mg# (42–47) and low Al contents at the core followed by sieved zone and higher Mg# (64–66) and Al content at the rim suggesting convection and mixing phenomena. Some of the diopsides show reverse zoning also with increasing Mg# from the core (58) up to 68 at the rim suggesting mixing. In some of the amphibole and clinopyroxene (Fig. 1b, c) phenocrysts primary sulfides (predominantly pyrrhotite) can be observed. The cumulate xenoliths (Fig. 1d) reveal different textures and are presented by hornblende (Fig. 1f), gabbro, pegmatoid gabbro with different proportion of the rock-forming minerals presented by amphibole (magnesiohastingsite), clinopyroxene (diopside) and plagioclase (bytownite-anorthite – Fig. 1h). Formation of amphibole by melt–clinopyroxene reaction is observed (Fig. 1g). Large crystals of apatite (Fig. 1e) are found in some of the xenoliths. The estimated pressure of crystallization based on the Al content in the amphiboles (Johnson, Rutherford 1989) is 5.3–8 kbar (for the porphyritic rocks, started the phenocrysts solidifying in depth, before the magma emplacement, while most probably some of the high-alumina ones are xenocrysts) and 6.3–7.4 kbar for the xenoliths.

On a primitive-mantle normalized diagram, the subvolcanic rocks show peaks in LILE (U, Th, Pb) and troughs in Nb, Ta, Ti and P that is typical for the orogenic arc magmas. They show high contents of LILE and steep LREE chondrite-normalized patterns and almost flat HREE normalized patterns. The rocks
have weak negative Eu (Eu/(Sm+Gd)/2) anomaly of 0.80–0.83, La/Yb ratio ranging from 13 to 15, high Sr (1340–1540 ppm) and low Y (16–19 ppm) content. The $^{87}$Sr/$^{86}$Sr(i) ratio of the subvolcanic rocks is 0.70435–0.70419 and $\varepsilon$Nd (-0.78/0.38) while that of a xenolith from pegmatoid gabbro is more primitive: 0.70350 ($^{87}$Sr/$^{86}$Sr(i) ratio) and $\varepsilon$Nd of 3.90.

The rocks have a few own magmatic zircons yielding a magmatic concordia age of 93.1±0.38 Ma (Fig. 1f). Several intervals for contaminated material of zircon xenocrysts are observed: 290–307 Ma (predominantly), 520–540 Ma, and 700–900 Ma.

**Conclusion**

In the area of the villages of Praveshka and Osikovska Lakavtsa are outcropping Upper Cretaceous intermediate subvolcanic bodies and dykes that represent an eroded volcano-plutonic system. Many xenoliths of cumulate lithologies are carried out to the surface by the subsequent magmatic impulses (including the mingling enclaves) suggesting formation of deep (lower) crust cumulates structure. The formation of amphibole-bearing cumulates beneath arc volcanoes is a key control on magma geochemistry and generates a hydrous juvenile mafic lower crust that is a good premise (after remelting and recycling) for formation of volatile’s abundant and probably mineralization productive (including adakite-like) magma(s).

**Acknowledgements**: The study is partly supported by Elatsite-Med JSC.

**References**
