The Sakar batholith – new look at its petrology, geochemistry and magmatic evolution

Сакарският батолит – нов поглед към неговата петрология, геохимия и магматична еволюция

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Occupying the core of a large dome-like structure of high metamorphic rocks in Southeastern Bulgaria, the Sakar granitoid batholith has been an object of conflicting interpretations for a long time. Lots of contradictory speculations about its structure, emplacement age and significance for regional correlations have been raised in our literature. Considered as Caledonian, Hercynian, Late Jurassic or even Early Cretaceous in age, the batholith still evokes professional curiosity.

On the basis of extensive re-mapping and a large set of laboratory analyses carried out by 1987, we presented quite a while ago some brief information concerning the petrographical units, structural peculiarities, emplacement mechanism and geochemistry of the rocks in an extended abstract (Vergilov et al., 1986). A paper devoted to petrology and geochemistry of the pluton was accepted for publication (Kamenov et al., 2010), but the principle conclusions and results of our work are still not familiar to our geological community. Actuated by the key-stone case of the batholith for every correlation, we aim here to revive our unpublished data in the framework of a modern overview on the mineralogy, petrology and geochemistry of the batholith, proposing a new model for its petrological evolution.

The granitoid rocks of the batholith and the high metamorphic basement are covered uncomformably by Permian (?) and Triassic sedimentary rocks. Some foliated granites emplaced within the metamorphic complex close to the southern margin of the pluton are referred to the Lessovo orthometamorphic complex (Kamenov et al., 1986) or to the so-called "Sakar type" schistose granites (Ivanov et al., 2001). Small bodies, mostly likely of Permian age, presented by metagranite porphyry and metarhyolites are exposed close to the southwestern and southeastern margin of the batholith. Basic dykes and various aplitic veins cut the rocks of the batholith.

The batholith is composed of the following granitoid units: 1) equigranular in the inner parts; 2) porphyroid with large microcline megacrysts in the outer parts, and 3) aplitoid small bodies. Large xenoliths of gneisses and orthoamphibolites occur in the marginal parts of the body. The modal petrographical species are quartz monzodiorite, quartz monzonite, granodiorite, granite, quartz syenite and leucogranite.

The main rock-forming minerals are separated from artificial heavy concentrates and studied optically, chemically, by X-ray and IR-analysis. No characteristic compositional differences are observed for the plagioclase composition in the equigranular and porphyroid granitoids (An_{30}–An_{10}), but plagioclases in the aplitoid granitoids are more acid (An_{15}–An_{10}). Albitization is observed in some places. Normal zoning is typical for the cores of the crystals and reverse one – for the intermediate and outer zones. K-feldspars are high ordered microclines ($2V_x$=87–81°; mean T1O=0.942 for the equigranular rocks, 0.905 in the porphyry varieties and 0.901 in the aplitoid varieties). Their rims are poorer in Sr, Ba, Li, Co and richer in Th and U in comparison with the cores. Biotite is a common variety with prevailing siderophyllite isomorphism. Oxidizing conditions of its crystallization are between the buffers HM and NNO. Muscovites are primary magmatic and secondary postmagmatic. Accessories are titanite, apatite, zircon, allanite and garnet.

The estimated crystallization conditions are moderate depth (between 13–15 and 8–9 km), low temperatures (cold granites), high pH_2O and pO_2, slightly increased alkalinity of the magmas.

Based on 147 new whole rock analyses for 36 elements, some specific petrochemical and geochemical features are revealed. The rocks are product of typically calc-alkaline metaluminous and peraluminous magmas referring mostly to high-potassium calc-alkaline, but also partly to calc-alkaline and shoshonitic series. The dome-like structure of the pluton is also expressed by constructing of lines of equal K_2O contents in the pluton. The following elements have compatible behaviour during the process of crystal fractionation: P, Cr, Sc, V, Co, Ni, Mo, Li, Ba, Sr, Zr, U and Th. Incompatible elements are: K, Rb and Ta. The elements with over Clark's concentrations are: U, Hf, Sc, Mo, Ni, V, W, whereas the elements Rb, Li, Cs, Zr, REE, Ta, As and Sb show below Clark's concentrations in the rocks.

REE chondrite-normalized patterns portray moderate enrichment of LREE to HREE which is typical for the marginal continental settings. No statistical important differences of the Eu anomalies between equigranular and porphyry granitoids are revealed, but the samples from the aplitoid granites delineate two models: one for the aplite-like granites and the other for the transitional in alkalinity leucogranites. The discrimination between both late acid varieties is successful on the diagramme Ta/Hf vs. Ba, where the deficient in Ba aplitoid granites and the richer in Ba transitional leucogranites are well separated. The porphyry granitoids do not show any correlation between the La/Sm ratio and $MgO/MgO+FeO+Fe_2O_3$ in contrast to the equigranular varieties. Chondrite-normalized REE patterns of the monomineral microclines and biotites disclose typical differences between their rock units.

Arguments for the origin of the rocks are sought through process geochemical modeling using the method of Cocherie (1986). The inference is that a crystal fractionation is required to explain the geochemical pattern of the rock samples. Late magmatic to post magmatic recrystallization is supposed for the formation of the microcline porphyry crystals. Mixed volcanic arc and postcollisional discriminations argue for the presence of a mantle component in the magma source and for some crustal contamination of the magmas. Presumably, melting of amphibolite/basaltic rocks from the Lower Crust could generate the parental magmas, which produced the rocks of the batholith by differentiation, fluid input and postmagmatic reworking.

In conclusion, the basic findings of the present research is that the Paleozoic granitoid Sakar batholith is a product of a complex evolution, including partial melting of Lower Crust materials followed by fractionation of the mineral association femic minerals + plagioclase and complicated by some contamination with Upper Crust rocks and influence of fluid impact. Solutions with intermediate properties between diffusion and infiltration fluxes are responsible for the formation of the porphyroid granitoid unit. The exported out of the batholith K-ions by infiltration fluxes have fixed K_2O into the blastoporphyries of K-feldspars in the country rocks, misunderstood earlier as products of regional metamorphism.

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