GRANITOIDS OF Mt. CER AND Mt. BUKULJA AND THEIR SIGNIFICANCE FOR GEODYNAMICS OF THE SOUTHERN PANNONIAN REALM

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Abstract: The study presents new geochemical evidence of origin and evolution of Mt. Cer and Mt. Bukulja granitoid rocks and emphasizes their significance for geodynamics of the southern Pannonian realm. Petrogenetic implications which help in distinguishing two different models of gravitational collapse of the continental crust are reported. It is concluded that in the Dinarides (Late Paleogene) and southern Pannonian realm (Early/Middle Miocene), occurred fixed and free boundary divergent collapses, respectively.

Key words: granitoid, post-collision, orogen collapse, Dinaride, Pannonian Basin

INTRODUCTION

Tertiary geodynamics of Serbia is dominated by collision/post-collision tectonics that followed the final closure of the last Tethyan domain (e.g. Karamata et al. 1999). During the Early Tertiary occurred consolidation and subsequent collapse of the Dinaride branch of the Alpine orogen (hereafter Dinaride orogen) and later on, in the Neogene, it was superseded by the extensional collapse in the Pannonian basin. The granitoid plutons of Mt. Cer and Mt. Bukulja, along with adjacent smaller massives of Stražanica and Brajkovac, are situated along the junction of the southern margin of the Pannonian basin and northern Dinarides and their petrogenesis provide important implications for geodynamics of the southern Pannonian realm. In this study we draw attention to the granitoids of Mt. Cer and Mt. Bukulja, focusing on their petrogenesis based on new geochemical data including REEs and isotopes. In addition, we distinguish two different models of gravitational collapse of the continental crust in the Dinarides and southern Pannonian realm, respectively.

GEOLOGY, PETROGRAPHY AND AGE

The Mt. Cer and Mt. Bukulja plutons are situated in the west and central Serbia, respectively, and together with the smaller bodies of Stražanica and Brajkovac were referred to as the granitoids of the southern margin of the Pannonian basin (Figure). Many authors (e.g. Steiger et al., 1989; Karamata et al., 1992; Karamata et al., 1994; Knežević et al., 1994; Cvetković et al., 2000, Cvetković et al., 2001) distinguished these plutons from the granitoids of the Dinaride suite, from which they differ in age, petrography, geochemistry and metallogeny.

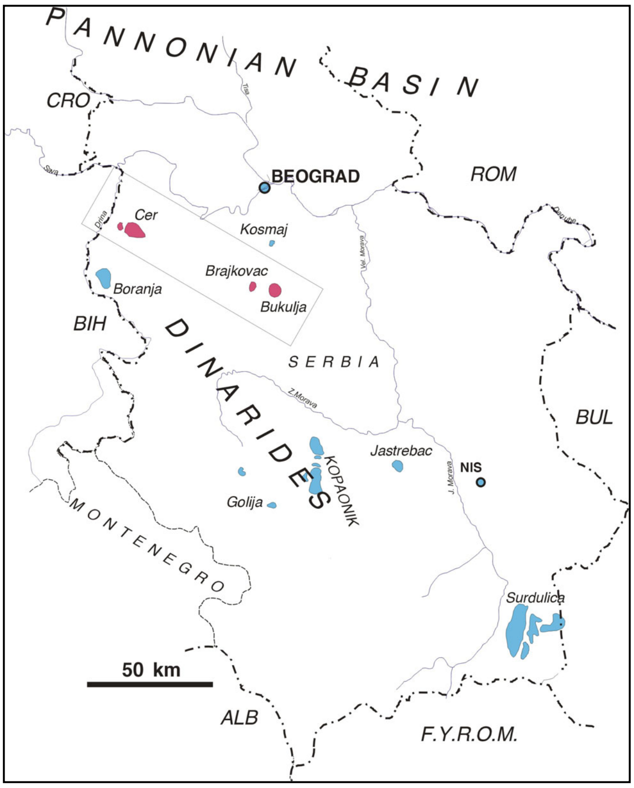

Figure. Geographical distribution of granitoid rocks of the Serbian part of the Balkan Peninsula; the frame shows the position of Mt Bukulja and Mt Cer plutons.

The pluton of Mt. Cer is an E-W stretching laccolith intruding Paleozoic metasandstones and metapelites displaying foliated marginal parts and a low-grade contact metamorphism (Knežević, 1962; Knežević et al., 1994). It is mainly composed of tonalite to monzodiorite (TMD) cut by dykes and smaller bodies of muscovite granite (MG). The TMD are hypidiomorphic granular rocks, composed of quartz, K-feldspar, andesine, hornblende and biotite as main minerals and titanite, allanite, epidote, zircon, apatite, rutile, magnetite and ilmenite as accessories. The MG appear as garnet-bearing and muscovite-rich types and they are generally composed of quartz, K-feldspar, oligoclase and muscovite as main constituents and biotite, garnet, tourmaline, apatite, zircon, rutile as accessories. Rarely, zoisite, titanite, pyrite, arsenopyrite and cassiterite may also be found.

Reported K/Ar ages for TMD range from 26 to 21 Ma (on hornblende) and from 19 to 16 Ma (on biotite and feldspar) while for the MG they range from 16 to 15 Ma (on micas) (Knežević et al., 1994; Pécskay, et al. 2001; Pécskay, unp. data).

The Mt. Bukulja pluton is a lens-shaped body intruding Devonian/Carboniferous low-metamorphosed schists in the west, and Cretaceous sandy marbles, clayey sandstones and limestones in the east, where a 3 km wide contact aureole of kornite, skarn and garnetite is developed. The pluton is predominantly composed of two-mica granite (TMG) whereas hornblende and biotite tonalite to granodiorite (HBBiTGD) were found in boreholes and/or deeply dissected parts of the pluton. TMG are mainly of medium-grained hypidio- to allotriomorphic texture, sometimes showing coarse-grained and porphyritic varieties. They are composed of quartz, K-feldspar, oligoclase, muscovite and biotite accompanied by titanite, allanite, apatite, zircon and ilmenite as accessories. In some more leucocratic varieties rare garnet and tourmaline may be also found. HBBiTGD form deeper parts of the Mt. Bukulja pluton and they show no clear field relations to TMG. HBBiTGD are hypidiomorphic granular rocks composed of quartz, andesine, K-feldspar, biotite and hornblende as main constituents and titanite, allanite and apatite as accessories.

Reported K/Ar ages for the TMG range from ~17 to 15 Ma (on micas) while K/Ar dating on hornblende gave an age of 28 Ma for the HBBiTGD (Erić, 2000; Pécskay et al., 2001).

GEOCHEMISTRY

Two petrogenetically different rock groups in Mt. Cer pluton and three in Mt. Bukulja pluton could be distinguished, based on field relations, petrography, geochemistry, including isotopes, and age.

TMD and MG in Mt. Cer pluton, show different SiO_2 contents ranging from 60.7 to 64.4 wt % and from 69.6 to 72.7 wt %, respectively. TiO_2, FeO, Fe_2O_3, MgO, CaO and P_2O_5 in TMD decrease with differentiation, while K_2O and Na_2O are almost constant. In the MG, Al_2O_3, K_2O and FeO decrease and Fe_2O_3 increases. V, Cr, Cu, Zn, Ga, Y, Zr and Nb in the TMD behave as compatible elements while Pb, Th and Rb as incompatible. TMD show higher Ba, Th, Ce and Zr and slightly lower Rb than MG. There are also differences in REE between the two rock groups with TMD having □REE up to 178 and Eu/Eu* around 0.7, and MG □REE up to 91 and Eu/Eu* from 0.5 to 0.6. Age corrected isotope ratios display values of $^{87}Sr/^{86}Sr$ around 0.708 and εNd from –3.6 to –5.6 for TMD and $^{87}Sr/^{86}Sr$ > 0.719 and εNd from –9.3 to –9.7 for MG.

In Mt. Bukulja pluton HBBiTGD rocks are counterparts of TMD of the Mt. Cer pluton. Within TMG, however, a low-K (TMGLK) sub-group is recognized. Silica range in HBBiTGD is 64.9-68.5 wt% and is higher in both TMG and TMGLK ranging between 69.6 and 72.9 wt%. All groups show similar variation trends on major element Harker diagrams, although data for TMG and TMGLK are somewhat scattered. HBBiTGD is richer in most trace elements than TMG and TMGLK. ΣREE for HBBiTGD is up to 242 while for TMG is less than 136. Initial isotope ratios revealed similar characteristics for HBBiTGD and TMGLK ($^{87}Sr/^{86}Sr$ 0.706-0.708 and εNd –2.4 to –4.4) in comparison to TMG ($^{87}Sr/^{86}Sr$ 0.708-0.712 and εNd –1.3 to –7.8).

ORIGIN AND EVOLUTION OF Mt. CER AND Mt. BUKULJA GRANITOIDS

On the basis of available geochemical data there is evidence that Mt. Cer TMD and Mt. Bukulja HBBiTGD originated by melting of lower crustal rocks (e.g. amphibolites equivalent to alkali rich or high alumina basalts). The melts formed, evolved through open differentiation processes (AFC and/or MFC) with fractionation mainly of plagioclase, hornblende, biotite, K-feldspar, and quartz.

Sub-parallel or crosscutting trends in major and trace element Harker diagrams between Mt. Cer TMD and MG and between Mt. Bukulja HBBiTGD and TMG, along with their differences in Sr and Nd isotopes and reported ages, rule out a genetic relation between TMD and MG, and HBBiTGD and TMG. On the contrary, they support that MG and TMG apparently originated from a different source which is more akin to upper crustal material. Major element chemistry of these rocks requires melting of metagreywackes, metapelites or similar source-rocks, which could have resided in higher levels of the continental crust during the late Early and early Middle Miocene. This upper crust segment was likely heterogeneous, both laterally and vertically, as may be inferred from the wide range of isotope ratios ($^{87}Sr/^{86}Sr$ 0.712 to less than 0.707) shown by TMG and TMGLK, with the latter having the lowest Sr isotope ratios. Although there is no field evidence indicating any relationship between TMGLK and TMG, all TMGLK occur at the northeastern part of the Mt. Bukulja pluton, probably suggesting the involvement of at least two batches of upper crustal melt in the evolution of this intrusion.

GEODYNAMIC CONSTRAINTS

The foregoing discussion implies that the Mt. Cer and Mt. Bukulja granitoid plutons have unique characteristics that can be related to their peculiar position at the junction of the Southern Pannonian realm and the Northern Dinarides. Here, at the same place, occur two types of granitoid rocks which formed under different geodynamic conditions. TMD of Mt. Cer and HBBiTGD of Mt. Bukulja originated in the Oligocene, more or less contemporaneously to other plutonic massives of the Dinarides, such as Kosmaj, Boranja, Kopaonik, etc. (Karamata et al., 1992; Karamata et al. 1994; Vasković, 1998). This was related to a gravitational orogen collapse, wrenching and formation of NNW-SSE elongated lacustrine basins (Marović et al., 1999). On the basis of the classification of Rey et al. (2001) it may be concluded that the post-collision phase in the Dinarides has features of a fixed-boundary collapse model. This type of collapse usually occurs through a transfer of gravitational potential energy from the elevated regions, i.e. orogenic domains, to the adjacent areas without giving rise to essential thinning of the crust. The lateral growing of the Dinaride orogen is evident from the presence of SW-vergent thrusts in the convergent-collision zone of the Adriatic plate and External Dinarides (Marović et al., 1999), whereas the activity of underplating, formation of lower crustal melts, such as TMD of Mt. Cer, HBBiTGD of Mt. Bukulja and analogous granitoids of the Dinaride suite, as well as complete absence of upper crustal magmas imply that no substantial crustal thinning occurred. However, from the Early Miocene onwards commenced the extensional collapse of the Pannonian basin (e.g. Balla, 1984, Royden, 1988; Horváth, 1993, Csontos et al., 1992 and references therein). Its southern realm greatly influenced the geotectonic framework of the northern Dinarides and probably some areas situated more to the south (?). In contrast to the Oligocene collapse in the Dinarides there is evidence that the Pannonian extension, at least in the early stage, was developed as a free-boundary divergent collapse (Rey et al., 2001) and was related to lateral extrusion of lithosphere blocks, subsidence of sedimentary basins and formation of shallow-dipping detachment faults (e.g. Bergerat, 1989; Dunkl & Horváth, 1995; Peresson & Decker, 1996). This model includes substantial thinning of the crust and can account for the formation of S-type granites, now exposed as MG at Mt. Cer and TMG at Mt. Bukulja. Updoming of hot mantle material beneath the Pannonian Basin is also inferred from high heat flow of around 100 mW/m^2 and asthenosphere depth estimates of around 60 km (Antal & Wesztergom, 2001).

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