MINERALOGY AND PETROLOGY OF THE BRNJICA GRANITOIDS (EASTERN SERBIA)

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ABSTRACT: The Brnjica pluton (tonalite, granodiorite, two-mica granite, leucogranite) is slightly peraluminous, having magnesiohornblende, Fe-biotite, oligoclase-andesine, and K-feldspar. Well-correlated trends are defined by major elements, which also indicate a pre-plate collision tectonic environment. Pressure of 2.3 to 4.1 kb and temperatures from 626 to 813 ^{o}C were calculated for TON, using co-existing hornblende and plagioclase.

Key words: East Serbia, Brnjica, granitoids, mineralogy, petrology, geochemistry

INTRODUCTION

Hercynian granitoids represent one of the most important and interesting geological units in eastern Serbia. They occur in different parts of the Carpatho-Balkan arc as elongated NNW-SSE directed zones, from the Danube River in the north to the southern slopes of the Stara Planina Mountain, at the Yugoslavian-Bulgarian border. One of the largest granitoid in eastern Serbia is the Brnjica intrusion, which covers an area of about 30 km^2. Its continuation to the north (Romania) is known as the Ljupkova-Sicevica granodiorite. New analytical data obtained on selected samples along with mineral microprobe analyses are presented in this paper as a first step in an attempt to contribute to the investigation of these rocks.

GEOTECTONIC SETTING AND GEOLOGY

The Eastern Serbia granitoids are probably related to the closure of the an ocean during the Cambrian-Ordovician, and the collision of neighbouring blocks (Radicevo gneiss granite), the docking in the early Carboniferous (Ziman gneiss granite), the subduction during the late Carboniferous (Suvodol, Vrska Cuka, Miroc and Plavna granites), and the post-collisional processes during the Westphalian-Permian (Gornjane and Ravno Bucje granites). Reported U/Pb, Sr/Rb and K/Ar ages of granites in the Carpatho-Balkan arc ranges from 259 to 342 Ma (Deleon et al., 1962), although they have been argued.

The Brnjica granitoid pluton occurs in the Kučaj terrane (Krstić and Karamata, 1992), the oldest rocks of which are the Proterozoic Osanica metamorphic rocks, followed by the late Proterozoic to early Cambrian "Green Complex". During the Variscian magmatism the Brnjica pluton intruded the above rock formations, as a late kinematic to post-kinematic intrusion, forming extensive thermal metamorphism (Vaskovic and Matovic, 1997 and references therein).

PETROGRAPHY AND MINERALOGY

The Brnjica pluton comprises (±hornblende)-biotite tonalite (TON), (±muscovite)-biotite granodiorite (GRD), two-mica granite (TMG), and leucogranite (LG).

TON, is medium- to coarse-grained, while porphyritic types with mostly K-feldspar and less mafic mineral phenocrysts, set in a finer groundmass, characterizes marginal parts of the pluton. It gradually turns into granodiorite, in places porphyritic, and granite. All TON rocks have plagioclase, biotite, quartz and some K-feldspar. Amphibole, in small amounts or traces, is present mostly at the periphery of the pluton. Basement xenoliths, and rare dark grey enclaves have been found.

GRD is composed of coarse-grained rocks with large, mostly euhedral K-feldspar megacrysts, which often give them a porphyritic texture. In places transitions to granite are found. Biotite is the only ferromagnesian mineral. Late and/or subsolidus muscovite is also present in small quantities although some grains have features of primary muscovite.

TMG occurs in the form of dykes of 10 to 500 m thick, intruding the TON and GRD. The typical mineralogy of TMG is K-feldspar, plagioclase, quartz, biotite and muscovite. Generally, TMG is represented by medium- to coarse-grained rocks. However, fine-grained facies, related to the margin of the dykes, have also been locally observed.

LG appears as thin elongated bodies at the eastern margin of the pluton, intruding concordantly gneisses. The rocks, whitish to grayish in colour, and inequigranular in texture, are composed of K-feldspar, plagioclase, quartz and muscovite. Apatite, zircon, monazite, magmatic epidote, allanite, titanite and opaques, mostly magnetite, occur as accessories in the various rock-types.

Plagioclase occurs in all rock-types (50-55 vol.% in TON, 25-35 vol.% in GRD, 22-33 vol.% in TMG and 15-24 vol.% in LG). It forms euhedral to subhedral prismatic crystals, which sometimes enclose tiny flakes of biotite, apatite, zircon and rarely monazite. In GRD and TMG plagioclase is often normally zoned with GRD having higher An% differences

between rim (19-28 An%) and core (24-38 An%) than TMG (rim, 24-30 An%; core, 26-31 An%). TON plagioclases show normal and oscillatory zoning either normal (core, 28-32 An%; intermediate, 30-38 An%; rim, 21-35 An%) or reverse (core, 30 An%; intermediate, 29 An%; rim, 34 An%). The oscillatory zoning probably indicates magma mixing, assimilation or changes in P_{H2O}. *K-feldspar* is main constituent in GRD (30-43 vol.%), TMG (35-45 vol.%) and LG (42-56 vol. %), while in TON is present in small quantities (1.5 to 5.5 vol.%), although in rocks having only biotite as the ferromagnesian mineral is higher (10 to 21 vol.%). It is mostly microcline perthite except TON where perthite is limited. Large grains enclose plagioclase and biotite. Its mean composition ranges from $Or_{95}Ab_5$ in TON to $Or_{91}Ab_8$ in LG. Ba content decreases from TON (0.91-1.78 wt.%) to LG (0.40 wt.%).

Hornblende occurs as subhedral to anhedral pale-green to dark yellow-green crystals. It is a magnesiohornblende, with Mg# = 0.51-0.59. Weak zoning within individual grains is reflected by enrichment of Ti in the core and fluctuation of Si and Al^{IV} among core, middle zone and rim, marked by decrease of Al and increase of Si in the middle or vice versa. The compositional variation are ascribed to double substitutions with edenite- and pargasite-type predominating. Based on Schmidt's (1992) Al-in-hornblende geobarometer and Holland and Blundy's (1994) geothermometer, pressure of 2.3 to 4.1 kb and temperatures of 626 to 813 ^{o}C respectively were calculated for the TON.

Biotite contents decrease from TON (6.5-15.5 vol. %) through GRD (3.5-9.5 vol. %) to TMG (2-8 vol.%). It is pleochroic yellow, brownish to red brownish. Sometimes it is associated with amphibole and coarse idiomorphic titanite. Often it has apatite, zircon and opaques (mostly magnetite) as inclusions. It is sporadicaly chloritized. All biotites are characterized as Fe-biotites. Mg# in TON, GRD and TMG biotites is 0.42-0.48, 0.33-0.48 and 0.40-0.49 respectively. The Mg-richest biotites (MgO=8.5-10.3 wt.%) are the ones co-existing with hornblende in TON, while TMG biotites are the richest in alumina (Al_2O_3 17.0-18.4 wt.%). On the discriminant diagrams of Abdel-Rahman (1994) the TON biotites clearly plot in the calc-alkaline field while the ones from GRD and TMG plot either in the calc-alkaline field or straddle the peraluminous/calc-alkaline fields. *Muscovite* occurs in TMG (~1-5 vol.%) as primary idiomorphic flakes often intergrown with biotite. In LG (15 vol. %) it is grown between feldspars as coarse flakes or as foliated fine-grained accumulation. Muscovite is TiO_2-richer in GRD (1.03-2.16 wt.%) and TMG (0.76-2.62 wt.%) than in LG (0.28 wt.%). The latter could be considered as subsolidus (Speer, 1984).

GEOCHEMISTRY

Selected major element variation diagrams for the Brnjica pluton are shown in figure.

SiO_2 in TON and GRD ranges from 64.2 to 68.25 wt.% and from 67.7 to 72.5 wt.%, in TMG is 73.8 wt.% and in LG 75.7 to 75.9 wt.%. In TON and GRD, TiO_2, Al_2O_3, Fe_2O_3t, MgO and CaO, decrease with differentiation forming well-correlated trends. Alkalies are rather constant in TON although some scatter is seen. In GRD Na_2O decreases and K_2O increases. All samples analyzed are slightly peraluminous (A/CNK=1.0-1.3). This is in contrast to the biotite chemistry. On the R1-R2 diagram of Batchelor & Bowden (1985), most of the Brnjica samples, particularly the TON and GRD, plot in field 2 of pre-plate collision granites.

CONCLUSIONS

The Brnjica intrusion is a composite pluton consisting of (±Hb)-Bi tonalite, (±Mu)-Bi granodiorite, two-mica granite, and leucogranite. Fe-biotite is the main ferromagnesian constituent in all rock-types except LG. Magnesiohornblende is present, in small quantities, only in TON. Muscovite is TiO_2-richer in GRD and TMG relative to LG. Plagioclase, often exhibiting normal and oscillatory zoning, ranges from An_{16} to An_{38} and K-feldspar (Or_{95-91}) is mostly microcline perthite. Pressure of 2.3 to 4.1 kb and temperatures from 626 to 813 ^{o}C were calculated, from co-existing hornblende and plagioclase in the TON. All major elements, except alkalies, decrease with differentiation, defining well-correlated trends.The rocks analyzed are slightly peraluminous (A/CNK=1.0-1.3) although the biotite chemistry is consistent with a calc-alkaline rather than a peraluminous character . A pre-plate collision tectonic environment is supported based on the R1-R2 discrimination diagram.

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