SKRUT GRANITOIDS FROM BELASSITSA MOUNTAIN, SW BULGARIA: CONSTRAINTS FROM ISOTOPE-GEOCHRONOLOGICAL AND GEOCHEMICAL ZIRCON DATA

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Introduction

The Skrut granitoids (Fig. 1) crop out over an area of about 13 km^2 in Belassitsa Mountain, SW Bulgaria, south of the village of Skrut and close to the border with Republic Macedonia. Bonchev (1920) described them for the first time as biotite-plagioclase granites with presumable Archean age. Later Bojadjiev et al. (1963) consider the intrusives as part of the Paleozoic "South Bulgarian granites". The data of the 1:25000 mapping (Zidarov et al., 1965, unpublished) were used for preparing the geological map 1:100 000 and the corresponding explanation (Zagorchev, Dinkova, 1991).

During the last years, the mineralogical and petrological studies of the Skrut granitoids assigned them as S-type granodiorites, and Rb-Sr whole rock isotope data suppose Jurassic time of magma generation (Zidarov et al., 2002). The present study focuses on the isotope and geochemical features of the zircons with the aim to specify aging, using U-Pb isotope single grain method and ID-TIMS technique. Zircon morphology and REE-distribution of the zircons are used to unravel the geochemical evolution of the magma. Zircon saturation thermometry contributes to constrain the temperature of magma generation.

Geological setting

The Skrut granitoids belong to the Ograzhden Block of the Serbo-Macedonian Massif (SMM). The pluton outcrops as one large and few smaller bodies (Fig. 1). Host rocks are high-grade metamorphic rocks – biotite gneisses and two-mica gneiss-schists, considered as the lower part of a complex thrust structure (Zidarov et al., in print). The contacts in the field are usually obliterated – covered by quaternary sediments, tectonic or tectonically reworked. The bodies are cross cut by granodiorite-porphyry dykes. At the eastern contact of the Skrut granitoids a small body of fine-grained granodiorites is emplaced, which is correlated with the Eocene Yavornitsa granite (Tarassova et al., 2001).

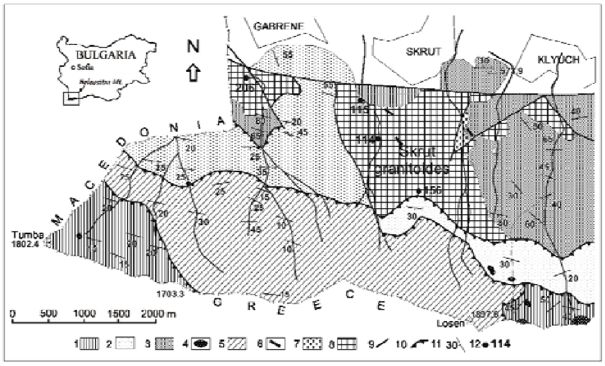

Fig. 1. Geological map of the Western part of Belassitsa Mt. (after Zidarov et al., 1965 and Zidarov et al., in print) with sample localities. 1- amphibolites; 2- two-mica gneisses and schists; 3- biotite gneisses; 4- serpentinites; 5- metagranites; 6- granodiorite-porphyry dykes; 7- fine-grained granodiorites; 8- Skrut granodoirite; 9- normal fault; 10- thrust; 11- schistosity; 12- sample location and number.

The deformations are unevenly developed in the porphyric Skrut granitoids, whereas the structure changes from almost massive (rare) to gneissic (prevailing). Plastic deformations lead to foliation of the micas and the feldspars. Mineral relations and structure suppose metamorphic overprint of greenschist to lower amphibolitic facies. Hydrothermal alteration is mostly limited along the Podgorski fault or is correlated with the Eocene dykes.

Petrology and geochemistry

The studied rocks are granodiorites, according to the classification of Le Maitre et al. (1989) and TAS (Zidarov et al., in print). On the SiO_2 vs. K_2O diagram they plot in the field of the high-K calc-alkaline magmatic series. The granitiods are mesocratic, medium-grained, porphyric after K-feldspar (porphyries are from 1-2 to 10 cm in size). The main rock-forming minerals are plagioclase (30-50%), potassium feldspar (6-22%), quartz (16-30%) and biotite (9-22%). Accessories are apatite, allanite (Tarassova, Tarassov, 2004), zircon,

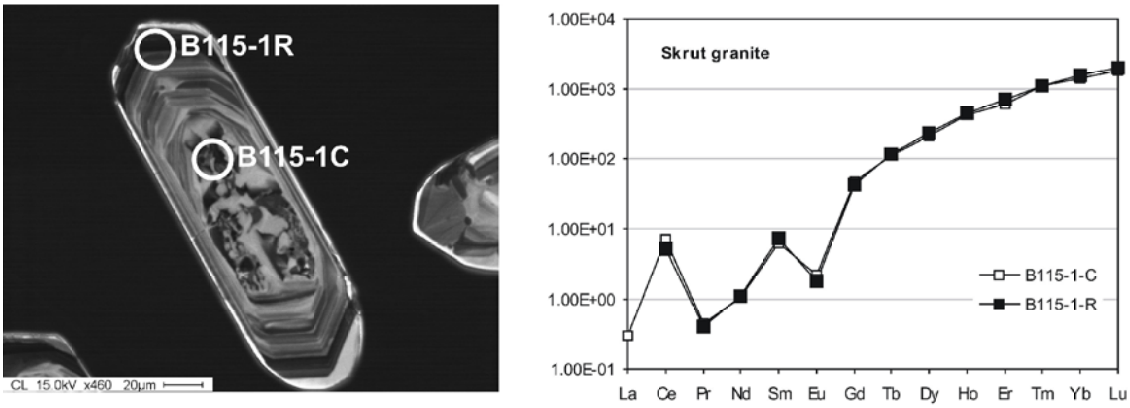

Fig. 2. Cathode-luminescent (CL) picture of zircon from sample 115 with the corresponding chondrite-normalized distribution of the REE (LA ICP-MS analyses). Circles on the picture correspond to the laser ablation spot in the zircon crystals.

epidote, sphene and garnet, and secondary minerals – muscovite, epidote, chlorite, pyrite and quartz.

Main- and trace element geochemistry is used to define the source and tectonic environment of granite formation (Zidarov et al., 2002). The ASI coefficient (average of 1.07) defines them as weakly peraluminous and gives evidence for a crust-dominated magma source. On selected discrimination diagrams of Pearce et al. (1984) and Harris et al. (1986) Skrut granitoids plot mostly in the field of VAG and postCol granites.

Zircon typology

The zircons of Skrut granitoids reveal dominating growth of the prism {*110*} and the bipyramid {*101*}. CL-images of the zircons show oscillatory magmatic zoning (Fig. 2), without dissolution surfaces and give evidence for high Zr-saturation of the melt. The prevailing morphological types, defined according to the typology method of Pupin (1980) are S_4, S_5, S_8, P_1, P_3, G_1. The typological evolution develops from the subtypes $S_{14\text{-}15}$ trough $S_{4\text{-}5}$ and ends with G_1. The zircon populations are characterized by relatively low I.T temperature indexes (340-360) and higher values of the index I.A (550-600). These features, as well the growth of the bipyramid {*101*}, suppose high alkalinity of the magma. The typological evolution trend of the zircons of Skrut granitoids overlaps with the calc-alkaline magmatic trend of Pupin (1980).

Zircon isotope geochronology and geochemistry

U-Pb zircon dating: High-precision U-Pb single grain method and ID-TIMS (Isotope Dilution – Thermal Ionisation Mass Spectrometry) technique are used for the dating of zircons from sample 115 (Fig. 1). We chose long prismatic beige grains with prevailing bipyramidal {*101*} and prismatic faces {*110*}. Two of the measured zircons are additionally abraded to avoid radiogenic lead lose from the rims, which are usually richer in uranium. For the calculation of the age the program ISOPLOT (Ludwig, 1998) is used. All corresponding points are concordant and yield a concordia age of 248.85±0.70 Ma (Fig. 3).

REE-distribution in the zircons: Chondrite normalized REE patterns of the zircons from samples 144 and 115 are similar and typical for igneous rocks (Hoskin, Ireland, 2000; Hoskin, Schaltegger, 2003; Belousova et al., 2002). They are characterized by decreasing LREE and steep encreasing of the HREE (Fig. 2). The positive Ce-anomalies give evidence for positive oxidation state of the magma, and the negative Eu anomaly is best explained with the fractionation of the plagioclase.

Zircon saturation thermometry: Zircon saturation thermometry (Watson, Harrison, 1983) is a simple and robust method of estimating magma temperatures. Solubility of zircons is very sensitive to temperature, but,

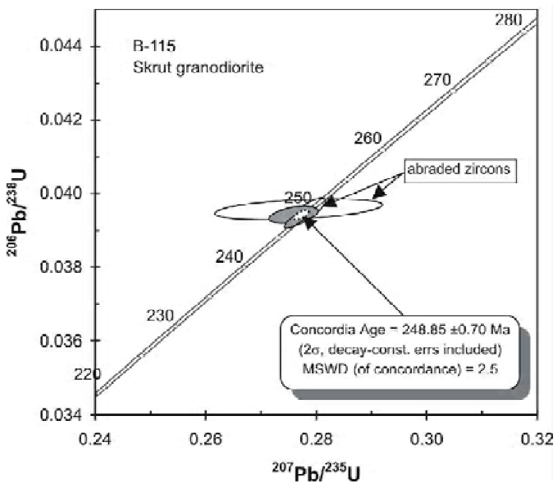

Fig. 3. Concordia diagram for zircons of sample 115, Skrut granodiorite.

in most cases, weakly sensitive to other factors (Miller et al., 2003). The possible transport of zircons as feno- and xenocrysts permits inferences to be drown for temperatures at which felsic melts are generated in the crust.

Zircon saturation thermometry is calculated using the equation of Watson and Harrison (1983), which rearranged for T yields a geothermometer for melt:

$$T_{zr} = 12900/[2.95 + 0.85M + \ln(496000/Zr_{melt})]$$

In this equation T_{zr} is the zircon saturation temperature in Kelvins (however all temperatures in the following text have been converted to °C), M is the ratio (Na + K +2*Ca)/(Al*Si), all in cation fraction, Zr_{melt} is the concentration of Zr in the saturated melt (measured in the rock sample) in ppm, and 496000 is the concentration of Zr (ppm) in the zircon.

The calculated zircon saturation temperatures of the Skrut granitoids range from 780 to 810°C, lying in the marginal field of the "cold" (T< 800°C) and "hot" (T> 800°C) granites of Miller et al. (2003).

Discussion and conclusions

The U-Pb high-precision zircon age of the Skrut granitoids 248.85±0.70 Ma is comparable with recently published data from the Igralishte granite 240+13/-9 Ma (Zidarov et al., 2004). In the Greek part of the SMM a possible candidate for correlation may be the "variably overprinted" (De Wet et al., 1989) Arnea granite, as its zircons yield ages from 210 to 230 Ma (single zircon evaporation method, Himmerkus et al., 2003). Noteworthy is the fact, that whole rock samples from both the Skrut and Arnea granitoids, define "isochrones?" with an age of 167.3±8.1 Ma (Zidarov et al., 2002) and 155±11 Ma (De Wet et al., 1989), respectively. It is still not clear, if these numbers reflect a real geological process, related to the evolution of the westerly situated Vardar zone, or are meanless errorchrones. The latter could result from mixing of two different primary magmas or from high-temperature overprint (metamorphism?). Missing isotope data on timing of the overprinting processes in Belassitsa Mountain hamper our proper interpretation so far.

Lower Triassic ages of granite magmatism in the SMM are still new in the geological literature (the newest time scale of the International Commission of Stratigraphy, 2004 is used, where the Perm/Triassic boundary lays by 251±0.40 Ma). Looking to the adjacent Rhodope Massif, I-type metagranites with a similar age, overprinted by the Late Alpine metamorphism, crop out in the Central Rhodopes (Cherneva et al., 1991). Upper Permian/Lower Triassic basic magmatism was recently also found in the Rhodopes (Liati et al., 2005; von Quadt, Peytcheva, this volume). All these facts suggest two possible scenarios to explain the formation of the Skrut granitoids and the almost contemporary felsic and basic magmatism: one is post-collisional collapse, thinning of the crust, allowing the intrusion of basic magmas, melting of the crust, as well as different mixing processes between the contrasting magmas; the second scenario suggests rifting (proposed by Himmerkus et al., 2003) or at least on setting of deep (trans)tensional faults, allowing intrusion of mantle and/or lower crustal magmas, and again melting of different parts of the crust and mixing.

Further studies will contribute to constrain the geodynamic reconstructions of the region – from the formation of the magmas to their geodynamic and metamorphic evolution.

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СКРЪТСКИТЕ ГРАНИТОИДИ ОТ БЕЛАСИЦА ПЛАНИНА, ЮЗ БЪЛГАРИЯ: ИЗОТОПНО-ГЕОХРОНОЛОЖКИ И ГЕОХИМИЧНИ ЦИРКОНОВИ ДАННИ

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Порфирните Скръткси гранитоиди се разкриват в западната част на Беласица планина в ЮЗ България. Вместени са сред биотитови гнайси и двуслюдени гнайсошисти на Сръбско-Македонския масив (СММ). Главни скалообразуващи минерали на тези гранитоиди са плагиоклаз, калиев фелдшпат, кварц и биотит, а акцесорни – апатит, циркон, аланит, епидот, титанит и гранат. Претърпели са неравномерно проявени процеси на динамометаморфизъм в зеленошистен и нисък амфиболитов фациес.

Преобладаващите морфотипове циркон, определени по тиположкия метод на Pupin (1980) са S_4, S_5, S_8, P_1, P_3, G1. Тиположката еволюция започва от субтипове S_{14-15}, минава през S_{4-5} и завършва с G_1, като съвпада с калциевоалкалния тренд на цирконите, установен от Pupin (1980). Сравнително високите IA индекси и по-ниски IT индекси на цирконовата популация, както и преобладаващото развитие на бипирамидата {*101*} предполагат висока алкалност на магмата. Цирконите показват наличие на характерна за магмени условия осцилаторна зоналност на растеж, без разтваряне на повърхността, което е белег за високо пресищане на Zr в топилката.

Температурите на насищане за цирконите от Скрътските гранитоиди са изчислени в интервала 780-810°C по метода на Watson, Harrison (1983). Хондритнормализираните разпределения на редкоземните елементи (РЗЕ) в циркони от гранитоидите са сходни и типични за магмени скали с обедняване на леките и обогатяване на тежките РЗЕ. Положителната Ce аномалия свидетелства за положителен окислителен потенциал на магмата, докато Eu отрицателна аномалия се свързва с фракционирането на плагиоклаза.

Възрастта на гранитодите е определена с конвенционален U-Pb метод по единични циркони като 248.85±0.70 Ma. Тя е сходна с тази на неравномерно деформираните Игралищенски (Огражден) и Арнеа гранити (Северна Гърция). С горнопермска – долнотриаска възраст са и протолитите на ортогнайси (I-тип) от Централните Родопи (Cherneva et al., 1991), еклогитизирани (Liati et al., 2005) и нееклогитизирани метагабра в Западни Родопи. Някои смесени корово-мантийни геохимични характеристики на Скрътските гранитоиди, както и данните за почти едновременна проява на базичен и кисел магматизъм по това време насочват към генериране най-вероятно в обстановка на постсубдукционна релаксация, свързана с орогенния колапс в края на палеозоя или към зараждането на дълбока разломна (рифтова?) зона. Бъдещите комплексни изследвания в района ще позволят изграждането на по-добре обосновани геодинамични модели.