The age and origin of the Chuchuliga and Rozino granites, Eastern Rhodopes

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Introduction

The Rhodope Massif is a region of widely distributed Late Alpine granitoid plutonism. In the last years the zircon dating of these granitoids in the Western and Central Rhodopes has demonstrated a range of ages from Upper Cretaceous to Lower Oligocene (Peytcheva et al., 2004; Ovtcharova, 2005; von Quadt, Peytcheva, 2005). However, an interesting group of granites in the Eastern Rhodopes, named Chuchuliga type (Ivanov, 1961), so far remained out of the extensive dating programs. Previous K/Ar muscovite data of the Chuchuliga granites gave absolute ages between 42 and 39 Ma (Priabonian) (Belmustakova et al., 1995). Based on field relationships, however, these granites have always been accepted as Upper Cretaceous in age. Thus, the intrusion age of the Chuchuliga type granites remained still unknown and of critical importance to understanding the geological history and geological setting of that part of the Rhodopes.

Here we provide the first U-Pb dating of zircons from two of the largest plutons (the Chuchuliga and Rosino granite), in addition we describe their petrography and present the first Sr and zircon Hf isotope data. In particular, our data suggest that the two plutons represent a continuation of the Srednogorie Upper Cretaceous magmatic activity on the territory of the Rhodope massif and that they originated from fractionation of a mantle-derived magma and assimilation of comparatively small amount of local crust (AFC process).

Geological setting

The Chuchuliga and Rosino granites are located in the Biala Reka dome. The latter is a north-trending metamorphic dome structure in the Eastern Rhodopes which is composed of basement of two high-grade metamorphic units, structurally overlain by a low grade Mesozoic unit (Bonev et al., 2006). The lower unit is composed of orthogneises and ultrabasic slivers of metaophiolites. The upper units consists of marbles, shists and gneisses and widespread metamorphosed ophiolitic peridotites and amphibolitised eclogites, intruded by metamorphic gabbros, gabbronorites, plagiogranites, and diorites of boninite and arc-tholeiitic affinities (Haydutov et al., 2004). The two units are separated by the Pelevun thrust. The Mesozoic unit is separated by the high-grade metamorphics by another low-angle detachment fault. The Chuculiga and Rozino granites are emplaced entirely within the upper tectonic unit with limited evidence for contact metamorphism.

In situ SHRIMP U—Pb zircon dating of a gabbro from the upper unit yields a Late Neoproterozoic age (572±5 Ma), whereas the outer zone of the crystals revealed Hercynian age (~300—350 Ma, Carrigan et al., 2003). Zircons from metagranites of the lower unit in the Biala Reka dome yield Late Paleozoic ages (from 320 to 305 Ma, Peytcheva, von Quadt, 1995 or 301±4 Ma, Carrigan et al., 2003).

Exhumation history of the upper unit (Bonev et al., 2006) range from about 65±3 Ma (dated by Rb-Sr on white mica from a pegmatite in Kimi complex, Mposkos, Wawrzenitz, 1995) to mainly 42—38 Ma in the lower unit (Peytcheva, 1997; Mukasa et al., 2003; Marchev et al., 2005).

Zr geochronology

Conventional single zircon U-Pb method and ID-TIMS technique are used for the dating of Chuchuliga and Rosino granites. Four out of 5 zircon grains of the Chuchuliga granite (sample AvQ-122, fig. 1) yield a Concordia age of 68.94±0.40 Ma, and one shows negligible lead inheritance. The zircons of Rosino granites show more complex composition. All five analyzed grains reveal inheritance (sample AvQ-124, fig. 2) and define a discordia line with

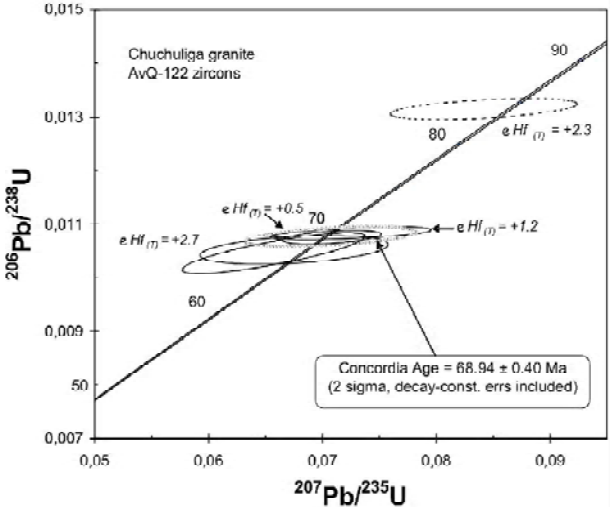

Fig. 1. Concordia diagram for zircons of sample AvQ-122, Chuchuliga granite. The ε-Hf values (corrected for 69 Ma) are written to the corresponding zircon grains

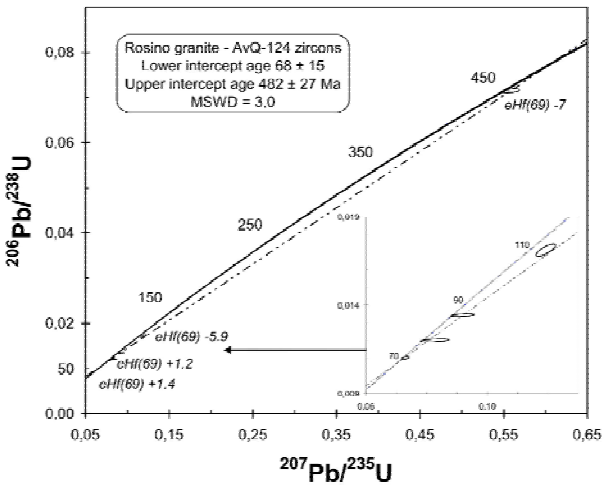

Fig. 2. Concordia diagram for zircons of sample AvQ-124, Rosino granite, with the corresponding ε-Hf values (corrected for 69 Ma)

lower intercept age 68±15 Ma (one grain is almost concordant by ~70 Ma) and upper intercept age of 482±27 Ma. As the majority of the zircons are closer to the lower intercept it is obvious that it is informative for the crystallization time of the granites. Within error uncertainties it coincides with the age of Chuchuliga granites.

Petrography and mineralogy

The first studies on the petrology of the Chuchuliga and Rozino plutons are completed recently by Belmustakova et al. (1995) and Stoykov and Mavroudchiev (1997). Here we briefly describe the chemistry and the mineral composition on the bases of published data and our new observations.

The Chuchuliga and Rosino plutons consist of medium-grained two-mica granites. The rocks are typically well foliated with foliation formed by oriented biotite and muscovite. The main rock-forming phases are plagioclase, K-feldspar, quartz, biotite, white mica. Accessory minerals are apatite, rutile, epidote and zircon. Plagioclase is compositionally homogeneous oligoclase (An_{20-23}). K-feldspar is perthitic microcline (Or_{88-90}), biotite is brown in color, iron-rich with Mg#37, high TiO_2 = 4.0—4.2 wt.% and Al_2O_3 = 18.9 wt.%. White mica has optical features and chemical composition favoring a primary origin and phengite composition (Si content = 6.3 on the 22 O bases).

Geochemical and isotope composition

Our analyses plot in the field of the larger data set of Belmustakova et al. (1995) and Stoykov and Mavroudchiev (1997). SiO_2 contents of the analyses of these authors range from 66.3 wt.% to 73.3 wt.% with majority of them ranging between 71 and 72 wt.% SiO_2. The rocks have typical calc-alkaline affinity with Na_2O content in most samples twice as much as K_2O. In terms of alumina saturation index, the granites are peraluminous. Trace element analyses show low contents in Nb, Y and Rb.

One apatite sample of Chuchuliga granite has been analyzed for Sr isotopes and revealed comparatively low $^{87}Sr/^{86}Sr$ isotope ratio (0.70616). It is in agreement with the mixed crust-mantle composition of the magmatic zircons in both granites, as they reveal slightly positive ε-Hf (corrected for 69 Ma) values from +0.5 to +2.7. The zircons with lead inheritance (sample AvQ-124) become crustal dominated with negative ε-Hf (69) values between —5 to —7 (fig. 1 and 2).

Crystallization conditions

Based on the two-feldspar geothermometers of Stormer and Whiney (1985) and Fuhrman and Lindsley (1988), Stoykov and Mavroudchiev (1997) estimated temperatures between 379—543°C with most of the temperatures within the range 422—520°C. Our new two-feldspar estimation, using Fuhrman and Lindsley's method also fall in this range. These temperatures obviously reflect postcrystallization reequilibrium.

More realistic temperature of ~650°C and pressure of about 6 kbar were obtained for the solidus of granitic magma with plagioclase composition An_{20} (Johannes, Holts, 1996), using the Massone and Schreyer (1987) phengite barometer.

Origin and relationship with the Upper Cretaceous Srednogorie magmatism

The comparatively low $^{87}Sr/^{86}Sr$ ratio (0.70616) of the Chuchuliga granite apatite and slightly positive values of the ε-Hf (t) in the Chuchuliga zircons (+0.5 to +2.7) suggest a mixed mantle-crustal source. These values, in an area with the exposed Paleozoic crust on the surface, having highly radiogenic composition ($^{87}Sr/^{86}Sr > 0.710$ at ~70 Ma, Peytcheva et al., 1998), are consistent with generation by crystal fractionation of a mantle-derived magma accompanied by comparatively small amount of crustal contamination by the local crust. The zircon from Rozino, which seems to have inherited Paleozoic zircons (482 ± 27 Ma), yielding the negative ε-Hf values, seems to offer the clue for the nature of the contaminant. Similar Early Paleozoic ages have been measured by Ovtcharova (2005) in zircon xenocrysts from porphyroclastic metagranites of the Borovitsa unit and metabasic rocks of Startsevo unit, which are the analogous to the variegated upper unit, hosting the Rozino and Chuchuliga granites. Inheritance of similar age and with same Hf-zircon characteristics is reported by Peytcheva and von Quadt (2004) for the Upper Cretaceous plutons in the southern parts of the Central Srednogorie. This facts clearly show that granites were contaminated either by the same or similar old crustal lithologies. The process was facilitated by the higher ambient temperature of the host rocks, which at that time seems to have been at depth of ~18 km.

Age determinations, made in the last years mostly on the granites from the Western and Central Rhodopes and North Rila Mountain exhibit variations between 69 Ma (von Quadt, Peytcheva, 2005) to 42 Ma (in Smilian, and Yugovo, Ovtcharova, 2005), with some shift from older to younger age from north to south. Comparison with the age of the Srednogorie volcanism, which shows a southward shift from 92 to 78 Ma indicates that the LateCretaceous granitoid magmatism in the Rhodopes seems to be a continuation of the Srednogorie type magmatism to the south.

Conclusions

The Chuchuliga and Rosino granites are two-mica granites having typical calc-alkaline character. In terms of alumina-saturation index they are peraluminous.

New U/Pb zircon ages (~69 Ma) confirm the geological observation for an Late Cretaceous age of the granites. This age is slightly younger then the ages of southernmost magmatic activity in the Srednogorie zone.

Sr-apatite and Hf-zircon isotope characteristics are consistent with the generation of the granites from a mantle derived magma which was contaminated with crustal materials and evolved through assimilation-fractional crystallization processes.

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Възраст и генезис на Чучулигинските и Розинските гранити, Източни Родопи

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Резюме. Чучулигинските и Розинските гранити са внедрени в горната единица на Белоречкия метаморфен ядрен комплекс на Източните Родопи. Наличните K/Ar възрасти на мусковит от тези гранити са в интервала на ранния палеоген (42—39 Ma), но на базата на геоложки основания те винаги са били считани за горнокредни. Ние представяме първите U/Pb възрасти на цирконите от двата гранита. Възрастта на Чучулигинските гранити е определена по конкордантни цирконите като 68.94±0.40 Ma. Наличието на наследено олово в цирконите от Розинския гранит е причина те да определят дискордия с възрасти по долно пресичане (информативна за времето на гранитообзуване) 68±15 Ma и по горно пресичане (даващо информация за асимилирания материал) 482±27 Ma.

Sr изотопни характеристики на апатит от Чучулигинския гранит (0.70616) и Hf изотопи на цирконите от Чучулигинския и Розинския гранити (от +0.5 до +2.7) подсказват за генезис в резултат на фракциониране на мантийно-генерирана магма, придружено с асимилация на сравнително малък процент коров компонент от Родопския фундамент.

Възрастта на Чучулигинският тип гранити, както и техните изотопни характеристики подсказват, че този магматизъм представлява продължение в Родопите на къснокредния континентално-дъгов магматизъм от Средногорската зона.