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Petrological, geochemical and isotope features of Lozen metagranite, Belasitza Mountain – evidence for widespread distribution of Ordovician metagranitoids in the Serbo-Macedonian Massif, SW Bulgaria

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Introduction

The Lozen metagranite is situated in the most southwestern part of Bulgaria, in the northern slopes of Belasitza Mountain, southern of villages Gabrene and Skrut (fig. 1), where they frequently formed the highest ground. The metagranite body, named after the peak Lozen (1897.6 m), is elongated in NW-SE direction and occupies around 6 km^2. By the geological mapping (M 1:25 000) these rocks are mentioned for the first time as porphyroblastic gneiss-granites (Зидаров и др., 1966). Metagranitoids with Ordovician age, comprising the greater part of the Ograzhden and Maleshevska Mountains have recently been described (Zidarov et al., 2003). The goal of this study is to display the main petrological and isotope-geochemical peculiarities of the granite protolith of this body and to show that these rocks have the same petrological, geochemical features and age as the widespread in Ograzhden Mountain Ordovician metagranitoids.

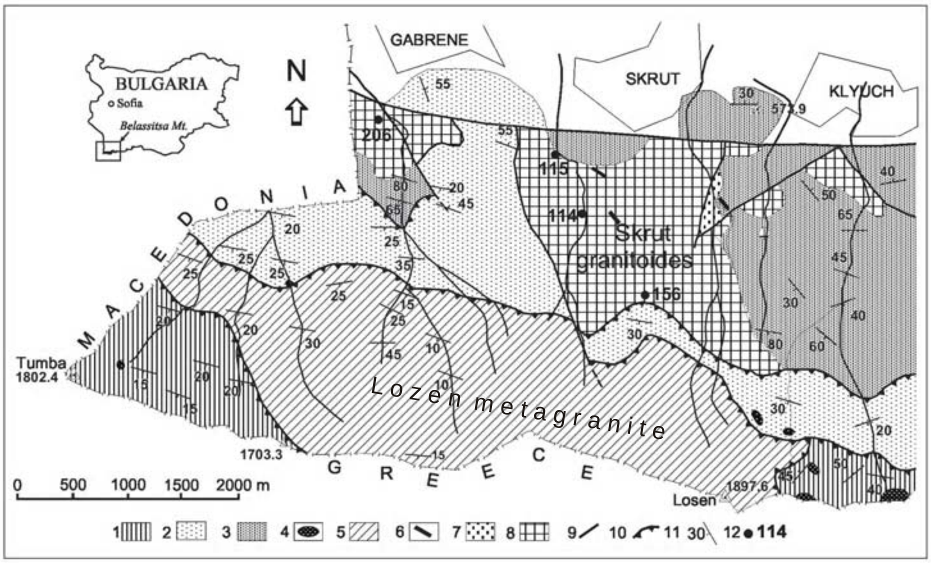

Fig. 1. Geological map of the western part of Belasitsa Mountain (after Zidarov et al., 1965 and N. Zidarov, D. Angelski, unpublished). 1. Amphibolites; 2. Two mica gneisses and Pl-bearing schists; 3. Biotite gneisses; 4. Serpentinites; 5. Lozen metagranites; 6. Granodiorite dykes; 7. Smallgrained granodiorites; 8. Porphiritic Skrut granodiorites. 9. Fault; 10. Thrust; 11. Schistosity

Geological setting and field observations

The examined region belongs to the Ograzhden unit of the Serbo-Macedonian massif (Zagorchev, 2001) according to its regional tectonic position. The metamorphic basement is build up of high grade metamorphic rocks: plagioclase-bearing schists, gneisses, metabasites and metaultrabasites. In its present geological position the Lozen metagranite appears as ~350 m thick sheet, underlined by the strongly mylonitized plagioclase-bearing kyanite-garnetiferous schists and is tectonically overlain by the amphibolites (fig.1).

Lozen metagranites are medium- to coarse-grained, equigranular to porphyritic, with alkali-feldspar porphyroclasts up to 5 cm in size. Elongated melanocratic enclaves and biotite-rich schlieren are abundant in an unevenly deformed metagranites. The enclaves are usually foliated parallel to the fabric of the metagranites and are flattened in the plane of the foliation. Foliated aplite dykes are also present. Regional foliation, fold axial planes and all linear fabrics within the country rocks and in studied metagranites dip consistently towards the south-southwest.

The contacts between the metagranite and the structurally overlaying amphibolites is sharp and conformable and is interpreted as a low angle southwest dipping shear zone, along which the granite protolith in the lower plate has been strongly mylonitized and transformed to finelayered mylonites. Near the both contacts metagranites are strongly folded in decimeter folds.

Petrography and mineral chemistry

Lozen metagranites display a porphyroclastic texture characterized by large megacrysts of K-feldspar within a more ductile fine- to medium-grained matrix of quartz, muscovite, biotite, plagioclase and potassium feldspar which is deflected around the megacrysts. In weakly deformed parts except potassium-feldspar, also biotite and plagioclase are preserved as relic magmatic minerals, mainly poikilitic included in K-feldspar porphyroclasts.

Most alkali feldspars (twined microcline) are now in the form of augen, but in areas of lower strain their euhedral habit is preserved. Feldspars behave in both plastic and brittle fashion, because size reduction occurs through grain boundary migration and/or subgrain rotation, and also through fracturing. Fractures are filled by finegrained agregates of plagioclase and quartz, but the presence of scarce white mica flakes along these fractures reveals the presence of small quantity of fluid phase. Typical "core-and-mantle" structure, characterized by a large feldspar core surrounded by a mantle of fine recrystallized grains, is very characteristic. Myrmekitized plagioclase at K-feldspar grain boundaries can be seen most notably on the long sides of inequant grains parallel to the S-foliation direction, which invariably faces the maximum finite shortening direction. In strongly deformed rocks feldspar augen are recrystallized to coarse polygonal aggregates, which points to a high temperature deformation. Relic plagioclase crystals are often included in K-fedspar augens. They are idiomorphic and with corroded edges, partially replaced by fine white mica aggregates. New formed plagioclase often is observed as recrystallized small polygonal grains, formed at the expense of magmatic crystalls. In more highly deformed parts of the rock these aggregates are interconnected, defining the foliation of the rock. In these cases it strongly resembles s.c. "foam texture". Relic biotite porphyroclasts are often preserved in rock matrix. They usually are kinked and observed in the central part of "mica fish" aggregates. White mica is rare and is formed at the expense mainly of magmatic biotite. Magmatic quartz grains are entirely recrystalized in coarse grained lenses. Deformation of quartz in mylonitic augen gneisses commonly results in the development of core-and mantle structure and "type-4" quartz ribbons (after Boullier, Bouchez, 1978) of elongated, preferably oriented, newly recrystallized grains. Serrated edges of large grains, the presense of subgrains and of deformation lamellaes point to the high temperature recrystallization mechanisms of the mineral via subgrain rotation and grain boundary migration. The augen gneisses also contain apatite, zircon and opaque as accessory phases. Near the lower contact of the metagranite body small garnet porphyroblasts are identified.

Mineral chemistry reflects the whole rock composition and the degree of diffusion during the metamorphic processes. The relic plagioclase is oligoclase (An_{31-34}), whereas the metamorphic generation is more albite-rich (An_{3-18}). Metamorphic K-feldspars are almost pure orthoclase, whereas relic grains are Ab-rich ($Or_{94-98}Ab_{2-8}$). All analyzed biotite flakes are Al-rich (^{VI}Al = 0.30—0.44 a.p.f.u.), wich coresponds well with the peraluminous character of the whole rock. They are slightly Fe-rich (f = 0.53—0.59) and on the clasification diagram fall nearer to the phlogopite-annite series. White micas are low temperature ferimuscovites-pherrifengites, because on Al_t-Si diagram they show deviation from the ideal muscovite-phengite series and do not contain Na in interlayer position. Garnet is almandine-grossulare type ($Alm_{61-64}Gross_{21-28}Spess_{6-11}Pyr_{3.5-3.9}$), which is typical for quartz-feldspar rocks.

The mineralogy of quartz-feldspar rocks is not suitable for geothermobarometric studies, and therefore estimations of P/T conditions of metamorphism are indirect. On the basis of mineral recrystallization textures, characterized by recrystallization of alkali-feldspar we can conclude that the temperature of metamorphism is relatively high (>500—550°C), but traces of migmatization are not observed.

Whole-rock chemistry

Major and some trace elements were analysed by XRF and by ICP on glass discs. All studied samples are corundum-normative, with A/CNK=molecular

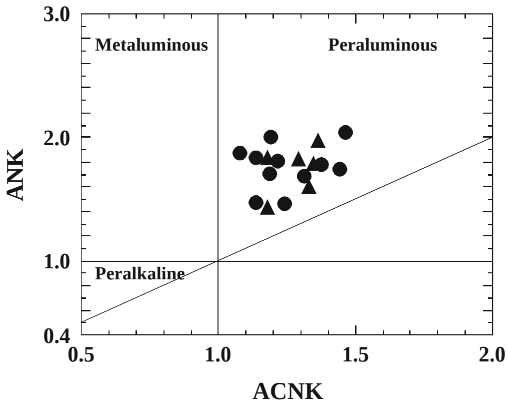

Fig. 2. Classification diagram A/NK-A/CNK of Maniar, Piccoli (1989) for Lozen metagranites (triangles). For comparison the data for Ograzhden metagranites are plotted (circles)

Al_2O_3/[CaO+Na_2O+K_2O) >1 (1.08—1.49), (fig 2). Therefore the rocks are peraluminous. Proportions of mafic components show a wide variety (2—10 wt.%), overlapping with the analysed samples from Ograzhden metagranites. Chondrite-normalized REE patterns show little variation, and resemble those of Ograzhden metagranites with УREE 130—234, La_N/Yb_N 5—13 and Eu/Eu* 0.44—0.80. Accepting the validity of Harris et al. (1993) modelling, that high Rb/Sr ratios (4—10) suggest granite formation at vapor-absent conditions (dehydratation melting), whereas Rb/Sr ratios <3.5 suggest vapor-present melting it would appear that most of the Lozen metagranites (with Rb/Sr 0.21—1.40) are formed by vapor-present melting. Spiderdiagrams for Lozen metagranite samples normalized to the average composition of the continental crust are characterized by distinct positive anomalies only for Pb. Normalization to the average composition of North American shale shows that only K and Ti have negative anomalies. Since we suggest that Lozen metagranites were derived by crustal meltig, trace element concentrations of the studied rocks were normalized to upper crust and the distribution show good resemblance.

Geochronology

A combination of precise single grain U-Pb ID-TIMS and *in situ* LA-ICP-MS methods are used for dating of zircons from the Lozen metagranites (sample A-31). They are combined with Hf-isotope studies of the same grains, which were analyzed for dating to unravel the sources of the magma. Three out of four long prismatic zircons are concordant and define a Concordia age 451.9±1.3 Ma (fig. 3A, fig. 4), whereas one grain is slightly discordant and shows negligible lead loss (generally at Variscan time). *In situ* LA-ICP-MS analyses are in agreement with the conventional data. Zones with magmatic oscillatory zoning in the three analyzed zircons define a mean $^{238}U/^{206}U$ age 462 ±17 Ma (2y errors), and inherited cores

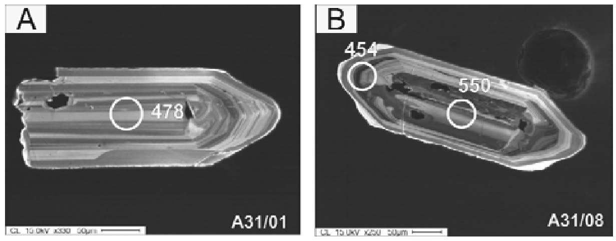

Fig. 3. CL images of zircons from sample A-31 (Lozen metagranite). The circles show the location of the LA-spots with the corresponding $^{238}U/^{206}Pb$ age data

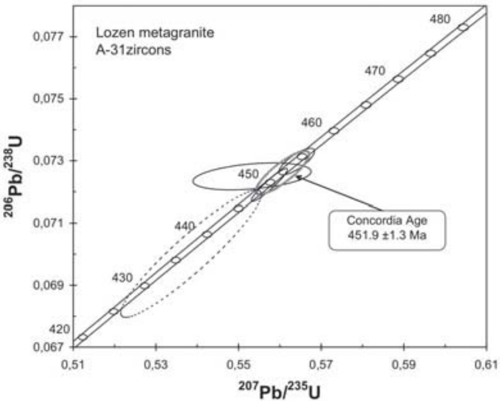

Fig. 4. Concordia diagram for zircons of Lozen metagranite (sample A-31)

in two zircons are 550—580 Ma old (fig. 3B). The magmatic age of the Lozen metagranite coincide within the error limits with the age of the Ograzhden metagranites, dated at 459.9±7.6 Ma (equigranular variety) and 451+18/—9 Ma (porphyritic variety) (Zidarov et al., 2003). The same is observed in the e-Hf characteristics of studied zircons: they range between —1.4 and —3.1 in the Lozen metagranites and between —2.6 and —4.4 in the Ograzhden metagranites. The identical age, zircon peculiarities and e-Hf source characteristics argue for a common origin of the rocks.

Conclusions

The studied metagranites are unevenly deformed and with Ordovician age (451.9±1.3 Ma) of their protolith. After their mineral composition, mineral (mainly biotite) and whole rock chemistry as well as according to their geological position, the Lozen metagranites may be referred to the group of biotite-rich tonalites to monzogranites after Barbarin (1996). The typology distribution of zircons from Lozen and Ograzhden metagranites give evidence for mainly crustal magma source and point to anatectic origin. The present new data show the widespread presence of Ordovician metagranites both in Belasitsa as in Ograzhden Mountains, ranging from 451+18/—9 Ma to 462±17 Ma. The identical age, zircon peculiarities and e-Hf source characteristics argue for a common origin of the rocks.

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Петроложки, геохимични и изотопни особености на Лозенския метагранит, Беласица планина – доказателство за широкото разпространение на ордовишки метагранитоиди в Сръбско-Македонския масив, ЮЗ България

Любомира Мачева, Ирена Пейчева, Албрехт фон Квадт, Никола Зидаров, Евгения Тарасова

Резюме. Лозенските метагранити се разкриват в билните части и северните склонове на Беласица планина в ЮЗ България, южно от с.с. Габрене и Скрът. Оформят удължено СЗ-ЮИ посока тяло с пластообразна форма и дебелина ~350 m. Вместено е между интензивно милонитизирани кианит—гранатови гнайсошисти и метабазити. Лозенските метагранити са средно- до едрозърнести, неравномерно деформирани скали с порфокластична по К-фелдшпат до равномернозърнеста текстура. В съответствие с това макроскопският им облик варира от слабо деформирани метагранити до очноивичести и ивичести гнайси. Характерна особеност на метагранитите е присъствието на дребнозърнести меланократни включения и биотитови шлири, които в интензивно деформираните участъци са силно изтеглени по посока на минералната линейност.

Минералният състав на Лозенските метагранити е представен от калиев фелдшпат, плагиоклаз, биотит, бяла слюда, кварц, апатит, циркон, рудни минерали. В близост с контакта с гнайсошистите присъства и гранат. От реликтовата магматична парагенеза са съхранени К-фелдшпат, биотит, плагиоклаз. Последните два минерала са запазени главно като пойкилитни включения в К-фелдшпатовите порфирокласти и показват характерните за магмени скали корозионни очертания. Микроструктурните особености на минералите, изграждащи метагранитите дават приблизителна информация за температурните условия на метаморфизма, които са >500—550°C. Изследваните метагранити показват подчертано пералуминиев характер (ASI= 1,08—1,49, който кореспондира и с богатия на Al биотит. Въз основа на анализ на съотношенията на редките елементи в Лозенските метагранити може да се направи извода за техния коров, анатектичен произход. Чрез използване на прецизни локални изотопни методи (U-Pb ID-TIMS и *in situ* LA-ICP-MS) на отделни цирконови зърна е определена ордовишка възраст на Лозенските метагранити (451.9±1.3). Тези възрасти, както и теренните, петроложките и геохимичните изследвания показват единния произход и широкото разпространение на ордовишки метагранитоиди, включени в различни тектонски единици на най-източните дялове на Сръбско-Македонския масив.