Source and age heterogeneities between the rocks of Lutzkan pluton

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Introduction

The Lutzkan magmatic complex belongs to the Kraishte tectonic zone of Bulgaria. It outcrops southern from the town of Trun between the villages of Ezdimirtzi, Velinovo, Erul and Milkiovtzi (Lutzkan pluton), in a small body northern of Trun and in the Rui Mountain (Rui pluton). The rocks of the complex intrude amphibolite facies metamorphosed rocks: biotite, muscovite and amphibole-biotite gneisses and amphibolites with presumed Precambrian age (Zagorchev et al., 1995). Belev (1960) considers the country rocks as part of the diabase-phyllitoid complex. The intrusive rocks of Lutzkan complex are covered by Permian sediments.

We present new petrologic, geochemical and U-Pb isotope data for the Lutzkan pluton. Traditionally it is regarded as complex magmatic body, built up by several phases, with clear successive relations between them. The first intrusive phase is represented by melanocratic gabbro-diorite varieties, which are followed up by granites and leucocratic aplitic granites. Transitional-alkaline, alkaline syenite and granite porphyries are described as the last magmatic phase. The distinction between all magmatic phases follows a logic and standard succession in the evolution of magmatism from more basic to acid varieties. The age of the pluton is accepted as Caledonian (Ordovician-Silurian — Belev, 1960; Zagorchev, Moorbath, 1987) or Variscan (Lower Carboniferous — Dragov, 1960).

Recent field observations

Our field observations showed that the relations between the magmatic phases are more complicated and ambiguous. Between the villages of Erul and Milkiovtzi basic dykes with gabbroic to diorite compositions intrude the biotite granodiorite. In the same localities strong variation and rapid facial change exist from "normal" granodiorite toward more mesocratic, rich in amphibole and biotite, varieties. Some textural and structural peculiarities of the latter (coarse grained quartz-feldspar zones and medium to fine grained amphibole-rich zones) imply processes of contamination or mingling of different magma batches. Additional evidences for such processes are the presence of mafic microgranular enclaves (MME), enrich in biotite and apatite, with diffusive contacts to the hosting granitoides. All these evidences permit to suppose contemporary existence of basic and acid magmas.

New terrain observations also confirmed that the intrusive rocks northern of Trun, near the Erma River, are gabbros and diorites in composition (not granitoids as shown on the geological map of Bulgaria 1:100 000).

Petrography and mineralogy

The rocks of Lutzkan pluton range from some very melanocrat varieties — hornblendites (Belev, 1960) to leucocrate aplitic granites.

Hornblendites are melanocratic and monomineral rocks. They have massive structure and panidiomorphe texture. These features are consistent with their magmatic origin as cumulates of basic or intermediate magma.

Gabbros and diorites are mesocratic, medium grained rocks, with massive structure. Within the contacts zone to the country rocks a weak schistosity can be observed. The texture is ophitic, with euhedral plagioclase and subhedral amphibole. The rocks contain plagioclase (50—70%), amphibole (25—70 %) and quartz (2—15%) as main minerals, whereas accessories are represented by apatite, allanite, and opaque minerals. Common secondary minerals are epidote and chlorite, plagioclase is replaced by sericite.

Granitoides show variable modal composition and they can be divided into several types. Amphibole granodiorites are medium grained, with monzonitic texture. The main mafic mineral is the amphi-

bole (15%), the rock also contains biotite (2—3%). With modal increase of the potassium feldspar the rocks change to amphibole monzogranite. Syenogranites with porphyric structures are the most leucocrate variety. Potassium feldspar is presented as phenocrysts, but also in the groundmass, biotite (2—4 %) is the solely mafic mineral. The accessory phases are apatite, titanite, zircon; allanite is in subordinate quantity.

All rock-types are strongly weathered and the primary mineral composition is modified. The composition of plagioclases in the diorites is andesine and show limited evolution: An_{50-38}. The composition of plagioclase from MME and the granitic hosts is identical: An_{13-9}, suggesting that exchange of components and reequilibration processes occurred. Amphiboles from MME and hosting granitoids are magnesium hornblende, with X_{Mg}=0.89—0.73, and significant [A]-site vacancy. An important part of amphiboles show disturbed stoichiometry, resulting probably from intensive alteration. The micas are biotites, with limited range in X_{Mg}: 0.56—0.50 and moderate TiO_2: 1.45—3.3 wt. %.

Estimation of intensive variables (*T, P and* fO_2) of magma crystallization yield hypabissal level of emplacement of the Lutzkan granitoides: P in the range 2.3—2.9 kbar (Al_t in Amph). Zircon saturation temperatures (Watson, Harrison, 1983) in granitoides are between 830—780°C. Direct crystallization of amphibole from the melt and the scarcity of replacement texture of amphibole over other mafic minerals (olivine, pyroxene) suppose important water content in the magma.

Geochemistry and isotope tracing

Two main rock-types are distinguished in the Lutzkan pluton on the base of the rock chemistry: one melanocratic with gabbro-diorite composition and another more leucocrate and with granodiorite—granite composition. Gabbro-diorites reveal calc-alkaline affinity, they are metaluminuous, and A/CNK varies between 0.7—0.9. For melanocratic varieties with MgO content up to 9 wt. % (Belev, 1960) a direct mantle origin could be supposed. Granitoids are meta- to peraluminuous with A/CNK between 0.74—1.2.

The two rock-types show distinctive alkaline contents. Gabbro-diorite varieties show very low K_2O Rb, Ba, Cs, Sr, Th, U contents, whereas granitoides are fairly enriched in K_2O, Rb, Ba, Cs, Sr, Th, and with important U content up to 21.4 ppm. Granitoides display fractionated trend of REE, La_N/Lu_N varying between 13 and 17 (fig. 1), and moderate Eu anomaly (0.68—0.69). Diorites show low fractionation of the REE with La_N/Lu_N — 4 and unimportant Eu anomaly: 0.8.

The spidergram (fig. 2) of the granitoides show pronounced LILE enrichment with positive peaks in Cs, Rb, Th, U, and less pronounced negative anomalies in Nb-Ta and Ti. With the transition toward to more compatible elements the trend is less fractionated. The diorites (sample Tr18) show an important negative Nb-Ta anomaly; their LILE/HFSE ratio is not so elevated as in the granitoides.

Age corrected Hf-zircon isotope data for the diorites (sample Tr18) range between +8.9 and +12.4 and suggest mantle magma source. The granite zircons (sample Tr11a) show mixed crust—mantle isotope signature with εHf between +0.63 and +2.6. For the microgranite dyke (sample Tr12) we obtain crustal dominated isotope εHf zircon values of —3.4 and —10.1.

U-Pb conventional and *in situ* dating

Conventional single zircon and titanite U-Pb analyses (ID-TIMS technique) are used for the precise dating of the two main rock varieties of the Lutzkan pluton. They are combined with in situ LA-ICPMS

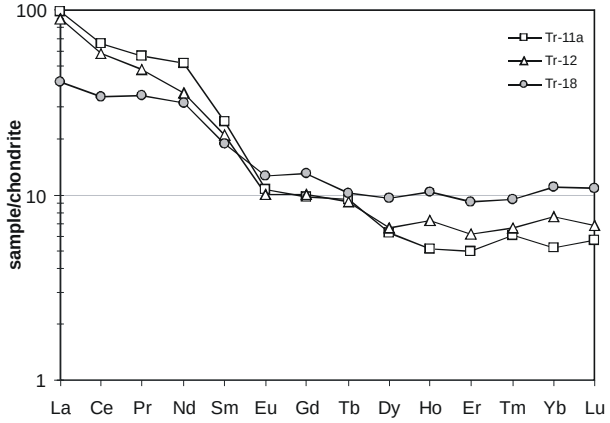

Fig. 1. C1 (Sun and McDonough, 1989) chondrite — normalized distribution of REE in samples of Lutzkan pluton

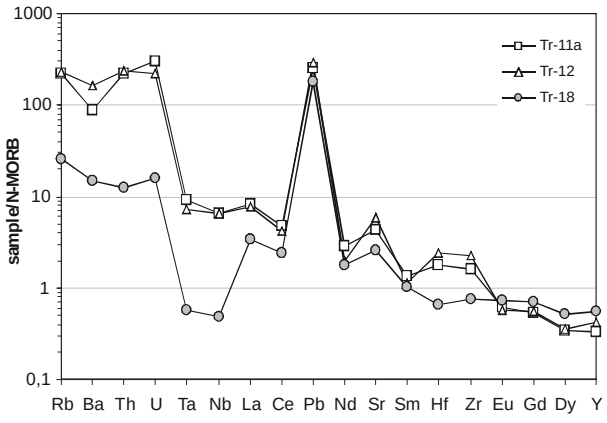

Fig. 2. N-MORB normalised (Sun and McDonough, 1989) spidergram for the rocks of Lutzkan pluton

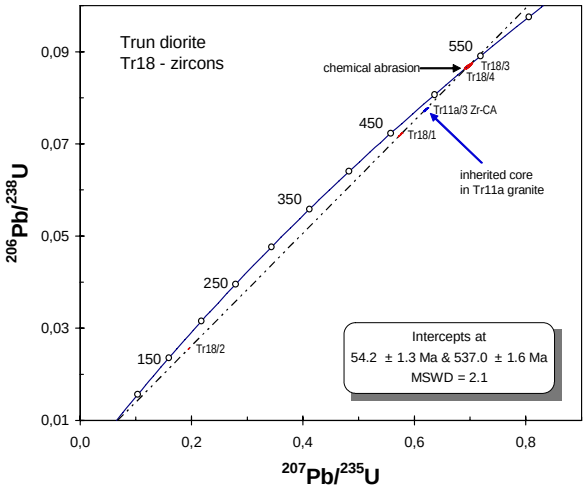

Fig. 3. Concordia diagram for zircons of sample Tr18. The age is calculated using all concordant (chemical abraded) and discordant zircons.

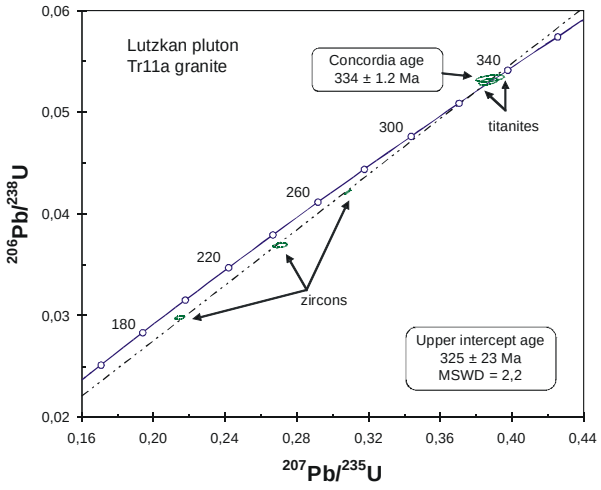

Fig. 4. Concordia diagram for zircons and titanites of sample Tr11a.

analyses of selected zircon grains. Zircons from the diorite (Tr18) show negligible recent lead loss, possibly related to Alpine events (fig. 3). Chemically abraded grains (Mattison, 2005) yield concordia age 537 ± 1.6 Ma (fig. 3). In-situ LA-ICPMS analyses are in agreement with these data, as generally the measured zircon domains yield mean $^{206}U/^{238}U$ age of 540 ± 12 Ma. No inherited cores are observed within the zircon grains, and the radiogenic lead loss is related only to the outer crystal zones.

Back scattered electron (BSE) and cathode luminescence (CL) images of zircons from granite sample Tr11a reveal strong metamictisation and inclusions of Th and U phases. Conventional U-Pb analyses are affected by the presence of inherited cores and radiogenic lead loss during Alpine time. Concordant age of 334.1 ± 1.2 Ma was obtained analysing two titanite grains of the same sample (fig. 4). In situ LA-ICPMS analyses on selected zircon crystals yield an age interval of 300—330 Ma for the magmatic zones and define a mean $^{206}U/^{238}U$ age of 310 ± 26 Ma.

Regional position, geodynamic implications and source considerations

The diorites and granitoides of Lutzkan pluton reveal different ages and distinct geochemical features. The diorites are Cambrian in age (537 ± 1.7 Ma) and can be correlated with the rocks of Struma Diorite Formation/Struma Unit (Lilov, 1981; Graf et al., 1998; Quadt et al., 2000; Kunov, 2003), which are exposed wider south of the Trun region. The diorites show εHf-zircon values between +8.9 and +12.4. They have flat HREE distribution, Nb-Ta and Ti negative anomalies, calc-alkaline affinity and slightly enrichment in LILE and LREE. All these features are consistent with a subduction-related geodynamic setting. Isotope and geochemical signature suggest a generation of magma in a subcontinental mantle lithosphere, which was enriched in LILE resulting from subduction related slab dehydratation.

The granitoids are Variscan in age (334.1 ± 1.2) Ma and collision- or post-collision related. They present elevated LILE/HFSE ratios, a fractionated trend of REE, important content of Th, U, K, and isotropic fabrics. The εHf-zircon isotope signature of granitoides indicates an important role of crustal material in the magma generation. Geochemical characteristics of the granitoids imply melting of crustal materials with mixed crust-mantle origin. Subordinate input of mantle components could explain the similarity in the distribution of some trace elements with the diorites, as well as the presence of MME and the chemical heterogeneity of the rocks.

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Източници и възрастови различия между скалите от Люцканския плутон

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Резюме. Новите теренни, петролого-геохимични, U-Pb и Hf изотопни данни показаха различни възрасти и геохимични характеристики за диоритите и гранитоидите на Люцканския плутон (Трънски район, Западна България). Диоритите са с камбрийска възраст (537 ± 1,7 Ma) и могат да се корелират със скалите на Струмската диоритова формация, разкриващи се по-широко южно от Трънския район. Диоритите показват εHf-цирконови стойности между +8,9 и +12,4, почти еднакво разпределение на HREE, Nb-Ta и Ti негативни аномалии, калциево-алкална тенденция и леко обогатяване на LILE и LREE. Тези свойства на скалите предполагат субдукционна геодинамична обстановка на формиране.

Гранитоидите са с варистка възраст (334,1 ± 1,2 Ma) и колизионни и/или постолизионни характеристики. Те показват повишени LILE/HFSE отношения, фракциониран тренд на REE, значителни съдържания на Th, U, K и εHf-цирконови стойности, предполагащи значително участие на корови материали при формирането им.