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Characteristic of Variscan granitoid magmatism in Tran region, Bulgaria

Momchil Dyulgerov[1], Irena Peytcheva[2], Rossen Nedyalkov[3], Albrecht von Quadt[4]

[1] Department of Mineralogy, Petrology and Economic Geology, Faculty of Geology and Geography, Sofia University "St. Kliment Ohridski", 15 Tzar Osvoboditel Blvd., 1504 Sofia, Bulgaria; E-mail: momchil@gea.uni-sofia.bg
[2] Department of Geochemistry and Petrology, Bulgarian Academy of Sciences, Acad. G. Bonchev str., bl. 24, 1113 Sofia, Bulgaria; E-mail: peytcheva@erdw.ethz.ch
[3] Department of Mineralogy, Petrology and Economic Geology, Faculty of Geology and Geography, Sofia University "St. Kliment Ohridski", 15 Tzar Osvoboditel Blvd., 1504 Sofia, Bulgaria; E-mail: rned@gea.uni-sofia.bg
[4] Department of Earth Sciences – ETH Zentrum, Institute of Isotope Geology and Mineral Resources, CH-8092 Zurich, Switzerland; E-mail: vonquadt@erdw.ethz.ch

Характеристика на вариския гранитоиден магматизъм в района на Трън, България

Момчил Дюлгеров[1], Ирена Пейчева[2], Росен Недялков[3], Албрехт фон Куадт[4]

[1] Софийски университет „Св. Климент Охридски", Геолого-географски факултет, бул. Цар Освободител 15, 1504 София, България
[2] Геологически институт, БАН, ул. Акад. Г. Бончев, бл. 24, 1113 София
[3] Софийски университет „Св. Климент Охридски", Геолого-географски факултет, бул. Цар Освободител 15, 1504 София, България
[4] Департамент по науки за Земята – ETH, Институт по изотопна геология и минерални ресурси, CH-8092 Цюрих, Швейцария

Резюме. Два вариски гранитоидни плутони се разкриват в Краището, Западна България: Люцкан и Руй. Руй е хомогенно двуфазно тяло и е изграден от монцогранит и аплитоиден левкогранит със силна метасоматична промяна наложена върху него. Люцканскят плутон е сложно устроен и е с няколко фациални разновидности. Монцогранитът е доминиращия магмен тип, гранодиорита и по-левкократните разновидности са рядко срещащи се. Плутоничните скали са последвани от дайки със сиенитов и гранитов състав. Наличието на дребнозърнести меланократни включения и мафични дайки, които са внедрени в гранитоидите на Люцканския плутон, са свидетелство за синхронно развитие на по-базичен магматизъм в изследваната област. Гранитоидите от двата плутона са I–тип, притежават метаалуминиев характер и линейни трендове на еволюция на главните петрогенни елементи. Дайките на Люцканскя плутон са с високо калиево съдържание и някои от тях с пералкален химизъм. Скалите от Люцканския и Руйски плутони показват значително набогатяване на несъвместими елементи: Sr, Rb, Ba, Th and U. Скалите от двата плутона са генерирани от набогатен източник в постколизионна геодинамична обстановка.

Ключови думи: вариски, гранитоиди, Трън, набогатен източник.

Abstract. Two Variscan granitoid plutons crop out in the Kraishte zone, Western Bulgaria: Lutskan and Ruy. Ruy is relatively homogenous two phase body and it is built up by monzogranite and aplitic leucogranite, with a strong metasomatic alteration overprinted on the leucogranite. Lutskan pluton is complex, with several facial varieties. Monzogranite is the most voluminous, granodiorite and leucocrate species have only local occurrences. The plutonic rocks in Lutskan are followed by the dyke activity with syenite and granite composition. Presence of mafic microgranular enclaves and mafic dykes that intrude the granitoids of Lutskan pluton attests for synchronous generation of more mafic magma. The granitoids from both plutons are I–type, have metaluminous character and linear tendency of evolution of major oxides. The dykes from Lutskan pluton have pronounced potassic character and some of them present peralkaline chemistry. The rocks from Lutskan and Ruy plutons show significant incompatible trace elements enrichment and notably Sr, Rb, Ba, Th and U. The rocks were generated from enriched source in postcollisional geodynamic setting.

Key words: Variscan, granitoids, Tran, enriched source.

Introduction

Variscan plutonic rocks cover substantial area in Western and Central Bulgaria. Their composition is essentially acid, as granitoids strongly dominate over other rock-types. The geodynamic position is considered as postcollisional, when emplacement of voluminous magma portions is possible in the brittle crust during the tectonic relaxation. Variscan granitiods form an elongated in west–east direction zone extending over 200–300 km, as all plutonic rocks are formed in a relatively short time span (Kamenov et al., 2002; Carrigan et al., 2005; Peytcheva et al., 2006, 2009; Dyulgerov et al., 2006). Mafic rocks (gabbro and diorite) are not typical and are weakly represented as small plutons in Central Srednogorie and as mafic enclaves in granitoids from Petrohan pluton (Peytcheva, von Quadt, 2004; Tacheva et al., 2006).

Lutskan and Ruy plutons are situated aside from the zones of the main Variscan magmatic activity operated in Stara Planina and Sredna Gora. Correlation with other Variscan magmatic rock is impeded because these plutons belong to another tectonic unit (Kraishte zone) and existing tectonic reconstructions do not threat Lutskan and Ruy plutons.

In previous publications (see below) Lutskan pluton attracts attention because represents some features which distinguish it from other Variscan magmatic rocks: close association with more mafic rocks, gold mineralization (mine “Zlata”) and emplacement of perlalkaline dyke suite of syenitic and granitic composition. All these features place Lutskan pluton in the focus of the scientific researches since the mid 50-ies of the last century. The Ruy pluton has more simple composition, as only granitoids present. The intensive hydrothermal activity affecting the plutonic rocks does not lead to the formation of a hydrothermal ore deposit, and this fact predetermines the low economic interest to the Ruy pluton.

The first petrogrphic data for Lutskan pluton are reported by Tzankov and Janishevsky (1939). They note the presence of graniotids and gabbro in the mine “Zlata” and the surrounding area; also give brief information about the country rocks. Parvanova and Marinova-Chipchakova (1952) make detailed description of the peralkaline dyke rocks – its chemical composition and optical properties of rock-forming minerals. Belev (1960) provides a comprehensive study of Lutskan pluton: petrographic description of rock-types, their chemical composition, relationships between plutonic and hosted metamorphic rocks. He presents structural properties of the plutonic rocks and makes a summary about the tectono-magmatic evolution of the region. Dragov (1960, 1961) makes an overview of the geological structure of the region. He describes in details the gold mineralization, petrography of the Precambrian country rocks, and the Palaeozoic intrusive rocks. Dragov (1961) first gives information about Ruy pluton: presented rock-types and its chemical composition. Tonev (1964) summarises with critical remarks the geological information, the data on the plutonic magmatism (Lutskan and Ruy plutons and the evolved granite- and syenite porphyry dikes), gives geochemical data for the magmatic rocks and information about the gold, silver and barite mineralizations. He points at the fact that the barite vein mineralization is disposed in structures with the same direction as the evolved dikes and cut lower Triassic sediments. Tonev (1964) supposes a genetic relation between the evolved dikes that have high Ba contents and the gold and barite mineralizations.

General geology

Lutskan and Ruy plutons belong to Kraishte tectonic zone in Tran-Vlahina tectonic unit (Zagorchev et al., 1995). The rocks of the plutons build up the core of Tran anticlinoria. They intrude Precambrian bioite-muscovite, biotite-amphibole gneisses and amphibolites, Precambrian-Cambrian metabasites, Devonian argillite. The magmatic rocks are covered by Permian and Triassic sediments.

Lutskan pluton is situated several kilometers south from the town Tran (Fig. 1). It has ellipsoid shape (3x6 km), extended in north–south direction. It is regarded as a complex magmatic body (known also as Lutskan complex), comprising 4 intrusive phases: 1) gabbrodiorite, 2) gabbrodiorite porphyries, 3) granitoid, 4) differentiated syenite- and granite porphyry dikes (Belev, 1960; Dragov, 1961; Tonev, 1964). Small apophyses and dykes of gabbrodiorites and granites are inserted in the country rocks. The gabbrodiorites were considered in the literature as the first plutonic phase of Lutskan complex, followed by the granitoids (Belev, 1960; Dragov, 1961). The magmatic activity terminates with separation of dyke suite, consisting of potassic syenite and granite porphyries (Parvanova, Marinova-Chipchakova, 1952). Various veins (gold-silver, gold-wolframite and barite) postdate the main magmatic activity, imposing strong hydrothermal alteration on the rocks. Our recent observations established mafic dykes, cutting the granitoids and presence of dark, fine grained and oval magmatic enclaves. The contacts between enclaves and hosted granitoids are sharp or diffusive.

Lutskan pluton intrudes Precambrian high-grade metamorphic rock: gneisses and amphibolites and Upper Devonian argillites. In the southwestern part of the pluton granitoids are intruded by acid volcanic bodies with Paleogene age. The south and southwest parts of the pluton are covered by Permian sediments. Belev (1960) presumes the Low Paleozoic age of Lutskan pluton and that gabbroic, granitic and peralkaline magmatic rocks are product of processes of magma differentiation at deeper level of the crust. Dragov (1960) assumes the Hercynian age of

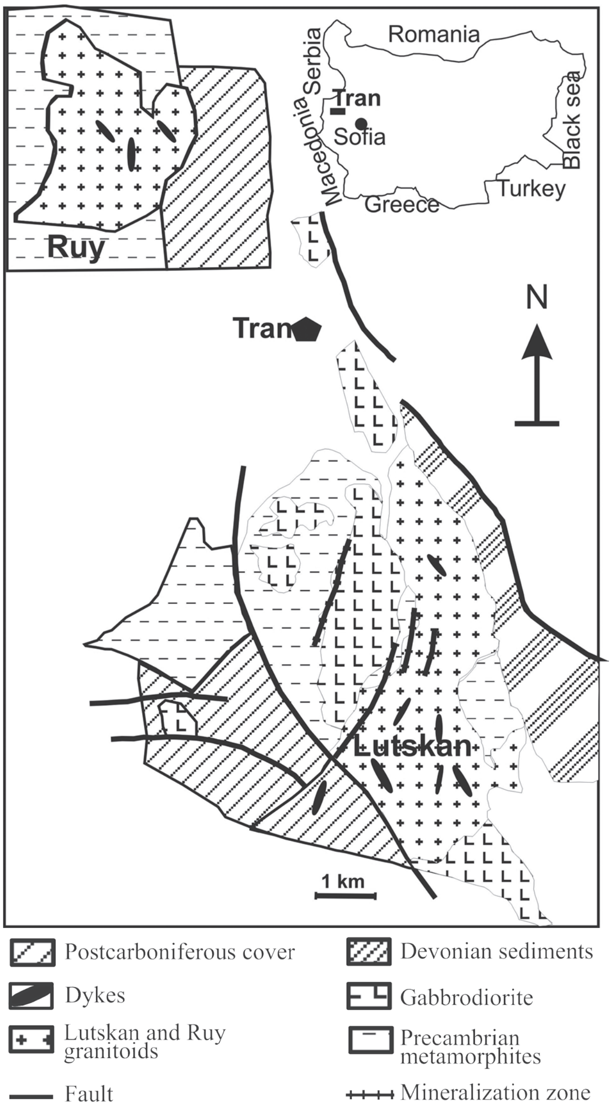

Fig. 1. Simplified geological map of the Tran region (modified, after Zagorchev et al., 1991)

Фиг. 1. Опростена геоложка карта на района на Трън (видоизменена по Zagorchev et al., 1991)

the Lutskan complex and that all rock-types are comagmatic. Zagorchev and Moorbath (1988) admit Silurian-Ordovician age for the rocks of Lutskan complex and provide poorly defined erochrone age of 414±75 Ma. Dyulgerov et al. (2006) and Peytcheva et al. (2009) established that gabbrdiorites and granites from Lutskan pluton belong to two separate magmatic events. Precision dating showed that the age of gabbrodiorite is Lower Cambrian – 537±1.6 Ma, whereas granitoids are Variscan – 334.1±1.2 Ma. Thus, by age and geochemical signature gabbrodiorite correlates to the rocks of Struma Diorite formation (volcanic-arc setting), whereas granite correlates to the other Variscan granitoids (postcollisional setting) from Western Bulgaria (Dyulgerov et al., 2006).

Ruy pluton outcrops on 10–12 km^2. It is inserted into Precambrian high grade metamorphic rocks (amphibolites and gneisses) which are thermally metamorphosed (Dragov, 1961). The northeast contact with Permian sediments, as well as southwest contact with Paleogene vulcanics is tectonic (Zagorchev et al., 1995). First petrographic description is given by Dragov (1961). He depicts the rocks as biotite-bearing leucogranite with modal variation toward aplitic varieties. Dragov assumes Low Paleozoic age for the pluton. Peycheva et al. (2009) dated the rocks as Variscan.

Petrography of the Lutskan pluton

Petrography of the granitoids

In conformity with the new age determinations the Variscan Lutskan pluton is regarded as comprising only acid intrusive rocks (granites and variable dykes: Table 1 and 5). The granitoids have massive structure, only close to the southwest contact with Permian sediments magmatic rocks are slightly sheared. In the zones with abundant hydrothermal activity (peak Chaplyak, “Zlata” and “Krushev dol” mines) the rocks show intensive cataclastic deformation, coupled with hydrothermal alteration. In this zones the rocks are whitened, the mafic minerals are often transformed in opaque fine phases and chlorite flakes.

We consider that Lutskan pluton is relatively homogenous and it is built up by one plutonic phase with gradual transitions between the observed facial varieties. According to the slight local variations in the petrography several rock-types can be distinguished (Table 1). The main part of the pluton comprises coarse grained, porphyroid on K-feldspar granite. It consists of potassium feldspar (30–55%), plagioclase (20–35%), and quartz (25–30%), thus both monzogranite and syenogranite species present. Mafic minerals are amphibole (3–10%) and biotite (1–5%); common accessories are apatite, titanite, zircon, rarely allanite. Medium to-fine grained monzogranite cuts the coarse grained varieties in the southwest part of the pluton – between Milkiovtsi and Krastato Darvo. The rocks have the same petrographic composition, but the cutting contacts attest that the fine grained variety represents small amount of local magma portion, intruded in already solidified rocks.

Granodiorite is rare and outcrops only in the central part of the pluton, in the upper parts of the river Pravna, under the peak Chaplyak. The rock is medium, equal grained and contain plagioclase (54%), quartz (22%), potassium feldspar (8%), amphibole (12%) and biotite (4%).

Northern part of the pluton, between the villages Velinovo and Glogovitsa, is made up by leucocrate monzogranite. It is medium grained, with ovoid quartz, visible in hand specimen, and strong hydrothermal alteration. Quartz, plagioclase and potassium feldspar

Table 1
Petrographic composition of the rocks from Lutskan and Ruy plutons

Таблица 1
Петрографски състав на скалите от Люцканския и Руйския плутон

Sample	Texture	Minerals					Accessories	Alterations
		Pl	Kfs	Q	Amph	Bi		
Lutskan pluton								
8 Tr	coarse porphyroid	25	43	29	3	rare	Ap, Tit, Zrn	Chl, Tit, oxides
10+ Tr	porphyroid	31	27	22	10	3		
11a Tr	medium granitic	55	8	21	12	4		Chl, Tit
13 Tr	anisotropic Amph-Bi schlieren	24	26	30	14	6	Ap, Zrn, oxide	Tit, Chl
22 Tr	coarse	18	49	22	5	5	Tit, Ap, Zrn, All	Chl
25 Tr	fine, porphyritic	35	28	22	8	5	Ap, Tit, Zrn, All	
39 Tr	medium	20	45	30				Ms, Ser, oxides
44 Tr	coarse, poicilitic	34	32	31	3			Ms, Tit, Ser
Dykes								
11 Tr	fine, granitic	20	53	8	10	8	Ap, Zrn	Chl
12 Tr	fine	30	30	30	4	4	Ap, Zrn, oxide	
13 Tr	fine	58		13	15 (Cpx)	20	Ap	
19 Tr	fine, porphyritic	28	40	25	4	2	Ap, Zrn	
24 Tr	porphyritic	65	27	8			Ap, Zrn	
25Tr	porphyritic	15	60	20	3	2	Tit, All, Ap, Zrn	
26 Tr	porphyritic	5	65	15	7	4	Ap, Zrn, oxides	Ser, Carb
Ruy pluton								
30 Tr	coarse	20	45	30	3	1	Tit, Ap, All, Zrn	Tit, Chl, Ep, Ser
31 Tr	granophyric	26	40	30	2	2	Ap, Tit, Zrn, All	Chl, Ep, Ser
33 Tr	aplitic	30	33	33	2	rare	Ap, Zrn, Tit	Ser, Ep, Chl, Tit
AvQ 244	medium	35	25	35	4	6		Ser, oxides
AvQ 246	coarse	30	37	27	4	2	Ap, Zrn	Ser, Ep

Mineral abbreviations: Pl, plagioclase; Kfs, potassium feldspar; Q, quartz; Bi, biotite; Amph, amphibole; Tit, titanite; Ap, apatite; All, allanite; Zrn, zircon; Ep, epidote; Chl, chlorite; Ser, sericite; Carb, carbonate; Ms, muscovite

are in equal amount, the solely mafic mineral is biotite (2–3%), completely transformed to muscovite+titanite aggregate. The transition between the most voluminous coarse grained varieties (porphyroid), and leucocrate, medium grained granite is gradual but very quick, with no cutting contacts and it is best visible just to the east from Glogovitsa. Dragov (1961) also notes the smooth transitions between the different rock-types and concludes that granite from Lutskan complex is a result of crystallization of one magma portion, with two main facial varieties. We admit that this leucocrate granite represents more evolved part of the same magma that built up the porphyroid, coarse grained facial variety. It is questionable whether the derivation of more evolved magma was a result of in-situ fractional crystallization or it was a second portion, inserted before the complete solidification of more voluminous porphyroid and coarse grained granite. The field evidences do not answer unequivocally to the problem. The fact that there are no contacts is in favor for evolution realized by in-situ differentiation. But the transition is in narrow intervals (several tens of centimeters to meters) and could be interpreted as evidence for existence of new magma batch, intruded in not solidified coarse grained granite.

More mesocrate, with undefined relations with the hosting granites, rocks outcrop on the road between the villages Milkiovtsi and Erul in the south part of the pluton. The rocks are medium to fine grained, porphyroid on K-feldspar. Schlieren of amphibole and biotite are abundant in the fine-grained groundmass, they form trails around plagioclases and give anisotropic structure with local enrichment of mafic minerals. This monzogranite is mesocrat, amphibole and biotite are up to 20%; apatite, allanite and zircon are the accessories. The mesocrat character and the schlieren of mafic minerals imply on the idea that this rock has experienced contamination with country rocks or mixing with more mafic magma. The evidences for the existence of mafic magma are the mafic dyke, outcropping nearby, and the mafic microgranular enclaves (MME). The MME are small, rounded, ovoid, dispersed in the granitoid rocks. The contact is lobate and gradual; rarely it is sharp, with chilling zone. The MME are medium to fine grained, composed of clinopyroxene (15%), biotite (30%), plagioclase (30%), quartz (20%), potassium feldspar (5%) and amphibole. Apatite is very abundant; other accessories are allanite and zircon. Between enclave and granites observes mutual invasion of material: biotite and clinopyroxen from enclave toward granite, and quartz and potassium feldspar in the opposite direction. Potassium feldspar in MME is anhedral, late, poiciliticaly enclosing plagioclase and mafic minerals, attesting that granite and mafic magma mixed in a liquid state. Another evidence for mixing in a liquid state is the presence of blade biotite and reaction texture in plagioclase (Hibbard, 1991). The very abundant apatite forms short prisms and no acicular crystals. It can be interpreted that the temperatures of granite and mafic magma do not differ significantly and the crystallization of the enclave was not by supercooling. This is supported by the scarcity of chilling zones between the enclaves and hosted granites.

Petrography of the dykes

The dykes are very abundant and show broad diversity. Their modal compositions range from melanocrate to leucocrate and hereafter are denoted as porphyries.

Melanocratic dyke with gabbrodiorite composition outcrops on the road between the villages Milkiovtsi and Erul. It is dark, fine grained, 3 m thick, inserted in coarse grained, porphyroid granite. Mafic minerals are around 35%; they show parallel orientation, forming magmatic foliation. The rock is composed of plagioclase, clinopyroxene, biotite and quartz; accessories are apatite, Fe-Ti oxide, titanite and zircon. Clinopyroxene (15–20%) is always euhedral, forms short prisms, with envelop or flakes of actinolitic amphibole. Biotite (15–20%) is euhedral to subhedral, often surrounding or developed on the pyroxene. Plagioclase (40%) is euhedral and prismatic, central zones are strongly sericitized. Quartz (20%) is the last crystallized, anhedral, occupying the intersticies between the earlier minerals.

Leucocratic dykes are very abundant, especially in the central part of the pluton under the peak Varpela and near Erul sometimes forming dyke swarms. Their composition is syenite, quartz-syenite to granite (Table 1). The dykes have massive structure and fine, and equal grained to porphyritic texture. They are yellowish, pinkish, and reddish. The rocks are composed of potassium feldspar (both as phenocryst and groundmass), plagioclase, intersticial quartz. Mafic minerals are biotite and amphibole in variable proportion; common accessories are apatite, zircon, and titanite.

Some syenitic dykes present specific features – contain sodic-calcic amphiboles, the dominant phenocryst is potassium feldspar (occasionally albite); biotite is rare or completely lacks (Parvanova, Marinova-Chipchakova, 1952). The rocks have massive structure and grey, dark red to violet colours. These syenite porphyries are fine grained, with porphyritic texture. The phenocrysts of potassium feldspar are set in a fine grained groundmass, composed of feldspars, quartz and prismatic or acicular amphibole. Biotite is rare, preserved only in the phenocrysts of K-feldspars; in the groundmass biotite is mantled or completely replaced by amphibole.

Petrography of the Ruy pluton

The rocks from Ruy pluton are leucocratic, strongly weathered, with abundant metasomatic alteration overprinted on them. The intrusive rocks are cut by massive quartz veins with E–W orientation. The structure of rocks is usually massive, close to tectonic zones shows shearing and sub parallel orientation of feldspar grains. Two granitoid types can be distinguished. The main part of the pluton is built up by coarse grained granite. The medium to-fine grained aplitic leucogranite is less abundant, outcrops mainly in narrow (several meters to tens of meters), elongated in submeridional (10–50°) stripes and has cutting contacts with the coarser variety. More voluminous part of aplitic granite is close to the eastern contact with hosted amphibolites. The aplitic granite closely associates with quartz veins and is strongly metasomaticaly altered.

The coarse grained granite have monzonitic, granitic texture, rarely observes phenocrysts of K-feldspars and plagioclase; granophyric and myrmekitic texture are restricted to the late anhedral feldspars of the groundmass. The rocks consist of microcline (35–40%), plagioclase (20–35%) and quartz (25–30%), thus monzogranite variety dominates over syenogranite one (Table 1). Mafic minerals are amphibole (2–3%) and biotite (1–3 %). Dragov (1961) noted that biotite is the main mafic minerals, as amphibole presents only close to the contacts. He admits that amphibole has external origin from the country rocks. Our observations established that amphibole is ubiquitous, and it is the main mafic minerals. Common accessories are apatite, zircon, titanite, allanite and Fe-Ti oxide. Posts magmatic alterations are extensive, mafic minerals are often replaced by chlorite+epidote+titanite aggregates, and feldspars are sericitized.

The aplitic leucogranite is fine and equal grained. It contains K-feldspars, plagioclase and quartz in equal amounts (~ 30–35%); mafic minerals (amphibole and biotite) are 0.5–2%. The structure is massive; the texture is alotriomorphe, monzonitic, myrmekitic. The rocks are densely cut by veins of quartz and sericite, imposing strong hydrothermal alterations on the magmatic minerals. Plagioclase and potassium feldspar (microcline) are sericitized, chlorite and epidote are developed on amphibole, and biotite is altered to chlorite. This granite can be regarded as second, more evolved phase of coarse grained granite.

Summary on petrography

Both plutons (Lutskan and Ruy) share many common features. Provisory there could be distinguished two phases/types with different petrographic characteristics: one coarse gained, and second fine grained, aplitoid. The contacts between them are in most of the cases transitional in narrow intervals (several tens of centimeters to meters). In some cases the contacts are sharp; this is well established in Ruy pluton. The first phase is composed by coarse- to medium grained, porphyroid on K-feldspar (up to 1 cm in size) amphibole-biotite monzogranite to granodiorite. The second phase is leucocratic, medium to fine-grained, equigranular, showing signs of weak deformation biotite granite. The repartition of the two granitoid types in the Lutskan pluton is on relatively bigger areas with different morphologies. In the Ruy pluton the distinction of the two phases is clearer due to the existence of cutting contacts between them. These geological, petrographic and morphological interrelations between the two phases let us suppose their intrusion in a short time interval. The two magma impulses differ by their differentiation level and probably by the activities of components as O, K, Na, Si leading to different rock textures and mineral compositions.

Some differences in the petrography in both plutons can be outlined. The rocks from Lutskan characterize with more important amphibole and biotite contents, whereas the rocks from Ruy are clearly more leucocrate (Table 1 and 5). Existence of shlieren of mafic minerals and MME in Lutskan pluton is evidence for processes of magma mingling and mixing, thus participation of mafic component was implicated in the evolution of the rocks. The dyke suite that follows the granitoid magmas differs in both plutons. In Ruy pluton it is uniform and comprises of aplites and pegmatites. In Lutskan pluton the dyke phases are highly variables and include aplites, pegmatites, granite porphyries, syenite porphyries and potassic peralkaline syenite and granite porphyries.

Mineralogy

Due to the strong hydrothermal alteration of the rocks of Ruy pluton only the composition of minerals from Lutskan pluton were analysed. Mineral chemistry was determined by electron microprobe (JEOL 733 Superprobe – EDS) at 25 Kev and accelerating potential for 100 seconds at EUROTEST-CONTROL Plc, Sofia.

Feldsaprs

Feldspars are the main minerals in the rocks from Lutskan and Ruy plutons. They are usually altered; common secondary products are sericite, epidote, and kaolinite. Potassium feldspar is relatively homogenous (Table 2); its composition is Or_{100-81}, Ab_{15-0}. Ba and Sr content were analysed only in K-feldspars from alkaline syenite porphyry (sample 24 Tr) where they form celsian component up to 3 mol.%.

Plagioclase is euhedral, lamellar, central zones are often strongly altered to epidote–sericite–carbonate aggregates. In granites and MME plagioclase composition shows late- to postmagmatic re-equilibration to almost pure albite: $An_{13.6-1.5}$ (Table 2). Plagioclase from melanocratic dyke is andesine (An_{44-38}) and probably represents primary magmatic composition.

Micas

Micas are ubiquitous mineral and present in all rock-types. They are usually affected by late- to postmagmatic alteration with abundant development of chlorite, titanite, and sometimes muscovite. The composition of mica presents limited variations and it is intermediate between the end-members phlogopite – annite – eastonite – siderophyllite and could be classified as biotite. The biotites from MME have higher X_{Mg} (0.58), than the biotites from granites and melanocratic dyke (Table 3). All studied biotites have relatively low Ti content: 1.45–3.35 wt.% TiO_2.

Amphiboles

Amphibole is the main mafic minerals in the granitoids from the described plutons. It is always euhedral, greenish, and the first crystallized mineral in the rocks. Amphibole forms prismatic crystals, sometimes

Table 2
Feldspar analyses of the rocks from Lutskan pluton

Таблица 2
Анализ на фелдшпати от скалите на Люцканския плутон

Sample	12 Tr	12 Tr	13Tr	22Tr	22Tr	22Tr	22Tr	22Tr	22Tr	24 Tr	24 Tr
SiO_2	63.29	68.33	57.97	62.68	65.69	63.52	64.32	64.58	63.55	64.31	64.10
Al_2O_3	18.62	19.10	26.82	18.89	20.42	18.71	18.40	21.83	21.83	18.81	18.41
FeOt	0.26	0.28	0.21	0.09	0.06	0.11	0.10	0.16	0.06	0.14	0.14
CaO	0.00	0.33	8.63	0.00	1.99	0.00	0.00	2.79	3.12	0.00	0.00
Na_2O	0.45	11.86	6.16	1.82	11.04	1.20	1.15	10.69	10.86	0.65	1.21
K_2O	16.26	0.00	0.05	14.26	0.20	14.58	15.25	0.06	0.16	14.71	14.51
SrO	n.d.	n.d.	n.d.	0.64	0.00	0.00	0.42	0.00	0.00	0.00	0.30
BaO	n.d.	n.d.	n.d.	1.72	0.12	1.46	0.00	0.12	0.00	1.56	1.40
Total	**98.88**	**99.90**	**99.84**	**100.10**	**99.52**	**99.58**	**99.64**	**100.23**	**99.58**	**100.18**	**100.07**
A	2.82	2.63	2.69	2.81	2.66	2.81	2.79	2.65	2.67	2.78	2.79
Si	2.97	2.99	2.59	2.94	2.91	2.97	2.99	2.85	2.83	2.98	2.98
Al	1.03	0.99	1.41	1.04	1.07	1.03	1.01	1.13	1.15	1.03	1.01
Fe^{3+}	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01
Ca	0.00	0.02	0.41	0.00	0.09	0.00	0.00	0.13	0.15	0.00	0.00
Na	0.04	1.01	0.53	0.17	0.95	0.11	0.10	0.91	0.94	0.06	0.11
K	0.97	0.00	0.00	0.85	0.01	0.87	0.90	0.00	0.01	0.87	0.86
Sr	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.01
Ba	0.00	0.00	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.03	0.03
Total	**5.02**	**5.01**	**4.97**	**5.05**	**5.04**	**5.00**	**5.01**	**5.04**	**5.07**	**4.97**	**5.00**
Or	95.96	0.00	0.30	81.23	1.07	86.51	89.71	0.32	0.83	90.93	86.47
Ab	4.04	98.49	56.20	15.76	89.79	10.83	10.29	86.95	85.59	6.11	10.96
An	0.00	1.51	43.50	0.00	8.94	0.00	0.00	12.54	13.58	0.00	0.00
Cn	0.00	0.00	0.00	3.01	0.20	2.66	0.00	0.20	0.00	2.96	2.56

Mineral formula based on 8 cations
Изчисляването на формулата е извършено на база 8 катиона

Table 3
Mica analyses of the rocks from Lutskan pluton

Таблица 3
Анализ на слюди от скалите на Люцканския плутон

Sample	12Tr	12Tr	12Tr	13Tr	13Tr	13Tr
SiO_2	39.03	35.46	35.87	37.13	37.19	37.35
TiO_2	2.25	1.72	1.55	2.35	2.05	2.17
Al_2O_3	11.80	14.30	14.11	15.85	15.10	15.77
FeO	17.79	21.06	21.23	19.83	20.61	20.00
MnO	0.45	0.39	0.41	0.10	0.17	0.26
MgO	12.93	12.29	12.30	11.01	11.62	11.28
CaO	1.69	0.00	0.00	0.00	0.00	0.00
K_2O	9.11	10.13	10.22	9.85	9.61	9.67
Total	**95.0**	**95.4**	**95.7**	**96.1**	**96.4**	**95.0**
Si	5.94	5.51	5.55	5.62	5.64	5.63
Ti	0.26	0.20	0.18	0.27	0.23	0.25
Al	2.12	2.62	2.57	2.83	2.70	2.80
Fe^{2+}	2.26	2.73	2.75	2.51	2.61	2.52
Mn	0.06	0.05	0.05	0.01	0.02	0.03
Mg	2.93	2.84	2.84	2.48	2.62	2.53
Ca	0.28	0.00	0.00	0.00	0.00	0.00
K	1.77	2.01	2.02	1.90	1.86	1.86
Total	**15.6**	**16.0**	**16.0**	**15.7**	**15.7**	**15.7**
mg #	0.56	0.51	0.51	0.50	0.50	0.50

Mineral formula based on 22 oxygens
Изчисляването на формулата е извършено на база 22 кислорода

forming trails and clusters, associating with apatite and zircon. Amphibole is in different degree affected by alteration: chlorite, secondary titanite, epidote and actinolitic amphibole are overprinted on magmatic amphiboles.

Analysed amphiboles from MME and zones adjacent to enclaves show that the composition of amphibole is magnesihornblende. These amphiboles characterizes with very high X_{Mg} (0.89–0.73), dominance of ferry over ferrous iron and low [A]-site occupancy (0.32–0.13). These features are in favour of relatively low temperature of crystallization. Elevated Fe^{3+}/Fe^{2+} ratio indicates oxidizing conditions during the final stages of crystallization.

Amphibole from the peralkaline syentite porphyries is prismatic or acicular, restricted to the groundmass and crystallized after potassium feldspar. Some rare phenocrysts show distinct zoning and reaction between early formed central zones and periphery, often central parts are completely reset. The amphibole has strong pleochroism in blue-green and violet colours and it is classified as arfvedsonite by Parvanova and Marinova-Chipchakova (1952). Amphibole composition varies from calcic to sodic-calcic. Presented species are magnesiohornblende, barroisite, richterite and magnesiokatophorite. Ca content ranges from 1.55 to 0.54 *apfu* and Na from 0.76 to 2.12 *apfu*, Ti content is low – up to

Table 4
Amphibole analyses of the rocks from Lutskan pluton

Таблица 4
Анализ на амфиболи от скалите на Люцканския плутон

Sample	MME	MME	24 Tr	24 Tr	24 Tr	24 Tr	24 Tr
SiO_2	45.4	46.03	49.97	53.33	50.01	49.62	50.15
TiO_2	0.57	0.67	0.23	0.44	0.32	0.54	0.41
Al_2O_3	7.22	7.96	5.98	1.77	5.35	2.93	3.58
FeO	16.01	16.55	12.86	18.96	11.05	16.96	14.79
MnO	0.41	0.39	0.43	0.36	0.29	0.25	0.37
MgO	13.69	12.68	15.7	11.53	16.98	12.24	14.47
CaO	10.57	10.84	9.50	3.46	10.14	4.70	4.80
Na_2O	1.83	1.64	2.76	7.40	3.06	7.08	7.68
K_2O	0.74	0.87	0.56	1.26	0.48	1.24	0.84
Total	96.44	97.63	97.99	98.51	97.68	95.56	97.09
FeO*	5.477	8.264	4.093	13.835	4.528	12.655	8.305
Fe_2O_3*	11.705	9.209	9.742	5.696	7.248	4.784	7.206
Total*	97.612	98.552	98.966	99.080	98.406	96.039	97.812
Si	6.671	6.725	7.083	7.782	7.117	7.490	7.331
^{IV}Al	1.250	1.275	0.917	0.218	0.883	0.510	0.617
Ti	0.063	0.000	0.000	0.000	0.000	0.000	0.045
[T]	**7.984**	**8.000**	**8.000**	**8.000**	**8.000**	**8.000**	**7.993**
^{VI}Al	0.000	0.095	0.083	0.086	0.014	0.012	0.000
Ti	0.000	0.074	0.025	0.048	0.034	0.061	0.000
Fe^{3+}	1.294	1.012	1.039	0.625	0.776	0.543	0.793
Fe^{2+}	0.673	1.010	0.485	1.688	0.539	1.598	1.015
Mn	0.051	0.048	0.052	0.044	0.035	0.032	0.046
Mg	2.998	2.761	3.317	2.507	3.601	2.754	3.153
Cr	0.000	0.000	0.000	0.000	0.000	0.000	0.000
[C]	**5.016**	**5.000**	**5.000**	**5.000**	**5.000**	**5.000**	**5.007**
Mg	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ca	1.664	1.697	1.443	0.541	1.546	0.760	0.752
Na	0.336	0.303	0.557	1.459	0.454	1.240	1.248
[B]	**2.000**	**2.000**	**2.000**	**2.000**	**2.000**	**2.000**	**2.000**
K	0.139	0.162	0.101	0.235	0.087	0.239	0.157
Na	0.185	0.161	0.202	0.635	0.391	0.833	0.929
[A]	**0.324**	**0.324**	**0.303**	**0.869**	**0.478**	**1.071**	**1.085**
Cations	15.324	15.324	15.303	15.869	15.478	16.071	16.085
mg #	0.817	0.732	0.872	0.598	0.870	0.633	0.756

Mineral formula based on 23 O, Fe^{3+} and Fe^{2+} are calculated according to stoichiometry
Изчисляването на формулата е извършено на база 23 кислорода, Fe^{3+} and Fe^{2+} са изчислени според стехиометрията

0.54 wt.% TiO_2 (Table 4). Amphiboles have important content of Fe^{3+} (0.54–1.04) and present magnesian character: X_{Mg} is between 0.60–0.88, attesting for relatively oxidizing conditions of crystallization, probably around or just above Ni-NiO buffer (Ernst, 1968).

Rock chemistry

The granitoids from Lutskan and Ruy plutons are essentially acid, with limited range in SiO_2 content in accord with relatively homogenous modal composition (Table 5.1). The modal and chemical compositions of plutonic varieties define the rocks as granites. The dyke suite from Lutskan pluton is more heterogeneous as the rocks vary from syenite to granite (Table 1 and 5.1). The syenitic dykes characterize with lower SiO_2 content and higher MgO, CaO, TiO_2, MnO, K_2O related to the distinctly higher amounts of K-feldspar and mafic minerals. Ruy pluton presents lower MgO, CaO, TiO_2, MnO contents, compared to Lutskan pluton. These features are consistent with the more leucocrate character of the rocks from this pluton.

The rocks from both plutons are dominantly metaluminous to weakly peraluminous, as A/CNK varies from 0.71 to 1.16 (Table 5.1). The peraluminous tendency is most pronounced in rocks, where parts of primary minerals are altered to sericite, chlorite and epidote aggregates (samples 11aTr, 12Tr, 33Tr). Thus, we consider that peraluminous character of some rocks is not a magmatic feature and does not reflect the primary chemistry of the magma. The dykes of syenite

Table 5.1
Major elements content of the rocks from Lutskan pluton and Ruy plutons

Таблица 5.1
Химически състав на скалите от Люцканския и Руйския плутон

Sample	11a Tr	10+ Tr	13 Tr	16 Tr	22 Tr	12 Tr	24 Tr	26 Tr	27 Tr	31 Tr	31 Tr	33 Tr	AvQ 244	AvQ 246
Pluton	Lutskan									Ruy				
SiO_2	71.68	68.15	66.93	67.22	66.65	73.99	66.39	63.37	63.81	70.61	69.89	71.28	73.18	71.46
TiO_2	0.39	0.52	0.58	0.57	0.44	0.46	0.73	0.60	0.77	0.20	0.17	0.18	0.14	0.19
Al_2O_3	13.33	11.91	12.92	15.36	13.85	13.09	13.29	12.37	12.59	14.42	13.91	14.48	14.49	14.44
Fe_2O_3	n.a.	2.67	1.30	1.09	2.06	n.a.	2.98	1.28	2.55	n.a.	0.73	0.56	n.a.	n.a.
FeO	3.05_t	2.35	3.28	2.64	1.88	2.67_t	1.44	2.66	1.99	2.04_t	1.38	1.47	0.94_t	1.16_t
MnO	0.05	0.06	0.08	0.07	0.08	0.05	0.09	0.04	0.07	0.04	0.03	0.02	0.02	0.03
MgO	1.95	0.91	2.54	2.92	1.75	1.05	1.52	3.44	2.32	0.60	0.90	1.39	0.10	0.23
CaO	2.47	2.89	3.37	2.36	2.68	1.21	1.71	3.19	2.86	1.46	2.23	1.28	0.32	1.42
Na_2O	3.16	3.99	3.31	3.36	3.25	3.41	3.30	3.34	2.23	4.26	4.38	6.99	4.91	4.24
K_2O	2.77	3.86	3.43	3.82	4.56	3.24	7.30	5.68	7.39	4.78	4.71	0.49	4.67	4.84
P_2O_5	0.35	0.33	0.54	0.39	0.61	0.27	0.93	1.08	1.16	0.15	0.36	0.30	0.12	0.14
H_2O^-	n.a.	0.16	0.19	0.14	0.22	n.a.	0.08	0.09	0.12	n.a.	0.14	0.18	n.a.	n.a.
LOI	0.42	1.07	0.58	0.63	1.95	0.25	0.50	3.02	2.36	0.58	0.66	0.96	0.85	1.68
Total	**99.62**	**98.87**	**99.05**	**100.57**	**99.98**	**99.69**	**100.26**	**100.16**	**100.22**	**99.14**	**99.49**	**99.58**	**99.74**	**99.83**
A/CNK	1.09	0.76	0.88	1.14	0.96	1.19	0.87	0.77	0.81	0.98	0.87	1.03	1.07	0.99
A.I.	0.61	0.90	0.71	0.63	0.74	0.697	1.00	0.94	0.93	0.84	0.88	0.83	0.91	0.85

The samples 11a Tr, 12 Tr, 31Tr, AvQ 244, AvQ 246 are analysed by XRF, the others by wet chemical analysis; A.I. – agpaicity index

porphyry are on the limit of Al_2O_3 undersaturation (Table 5; Belev, 1960; Dragov, 1961). The presence of mafic alkaline phases mainly in the groundmass reflects the evolution toward a peralkaline residue.

In Lutskan and Ruy plutons TiO_2, FeO, MgO, MnO, CaO, P_2O_5, diminish gradually (Table 5.1, Fig. 2). This is explained by fractionation of mafic minerals (amphibole and biotite), apatite and calcic plagioclase during the evolution of the magma. Al_2O_3 and Na_2O do not show significant variation in the rocks from both plutons. K_2O weakly diminish in Lutskan and this is related to the modal decrease of biotite. K_2O shows an evident increase in the dyke suite, where it reaches 7.56 wt.% in the syenite porphyries (K_2O 8.56 wt.% in Dragov, 1961). In Ruy K_2O is constant and does not show significant range in the plutonic rocks.

Fractionation of mafic minerals is also evidenced by the distribution of some transitional metals in the magmatic suites. Sc, Co and V gradually diminish in both plutons (Table 5.2, Fig. 2) and this is attributed to their incorporation into amphibole, biotite and opaque minerals.

The rocks from Lutskan and Ruy plutons are enriched in LIL elements (Table 5.2). Lutskan pluton has significant content of Cs, Rb, Sr and outstanding Ba content, reaching up to 4611 ppm in the alkaline syenite porphyries. LIL elements show constant high values, thus these are a primary magmatic feature and can not be attributed to the processes of magmatic differentiation. Ruy pluton presents less important enrichment in LIL elements, and notably in Cs. This could be explained with the more leucocratic character and with the smaller modal amount of biotite in the rocks.

HFS elements have more specific behaviour. All elements are enriched in the rocks of the studied plutons, but amongst these elements, two groups can be separated. In the first group Zr (169–309 ppm), Nb (22–34 ppm), Hf and Ta present important values, but the second group more incompatible Th (12–74 ppm) and U (7–49 ppm) have higher levels of enrichment in the rocks (Table 5.2). This is well illustrated on the multicomponent diagram where the left-side incompatible elements present steeper slope, whereas Nb, Ta, Zr and Hf show much flat patterns and less enrichment level (Fig. 3).

Lutskan and Ruy plutons can be distinguished in the terms of REE contents (Fig. 4). Lutskan pluton presents substantial enrichment with ΣREE (123–203 ppm), whereas the rocks of Ruy have moderate content (41–89 ppm). The distribution of elements on chondrite-normalized diagram in both plutons shows high degree of fractionation without significant variation between the rocks (La_N/Lu_N 10–19). Eu anomaly in both plutons is slightly negative, between 0.59 and 0.74.

The dyke of peralkaline syenite does not show significant enrichment in incompatible elements, compared to the intrusive rocks from Lutskan pluton. They plot on the same linear trends (Fig. 3 and 4) and these features can be regarded as evidence that the peralkaline liquid is a residue of the granitoid magma.

Granitoid type and source

Lutskan and Ruy plutons bear all characteristic features of I-type granitoids. They have metaluminous

Table 5.2
Trace elements content of the rocks from Lutskan pluton and Ruy plutons

Таблица 5.2
Съдържание на редки елементи в скалите от Люцканския и Руйския плутон

Sample	11a Tr	10+Tr	13 Tr	16 Tr	22 Tr	12 Tr	24 Tr	31 Tr	33 Tr	AvQ244	AvQ246
Pluton	Lutskan							Ruy			
Sc	7.3	11.9	14.1	12.1	8.6	7.7	15.6	4.3	3.5	2.3	4.1
Co	9	11	14	13	9	6	6	3	3	1	2
V	61	75	98	83	72	63	90	38	31	14	20
Mo	11	9	17	6	5	7	2	4	5	n.d.	1
Cu	7	45	36	42	13	14	31	47	47	4	7
Zn	108	400	51	78	35	85	51	31	26	21	31
Ga	52	27	28	25	16	86	18	17	18	16	18
Y	12	19	25	20	15	15	21	9	6	6	7
Cs	34	30	27	25	33	23	21	14	1	12	19
Ba	1236	2093	2333	2433	1730	2273	4611	2260	184	1104	1620
Rb	276	406	343	383	296	291	420	246	37	252	310
Sr	495	701	823	729	504	665	684	805	278	241	403
Zr	169	229	309	262	189	235	263	196	166	100	153
Hf	5.2	7.0	8.9	7.9	6.0	7.2	7.5	6.7	6.0	4.1	5.3
Nb	23	33	32	29	30	23	35	32	29	21	22
Ta	1.8	2.8	2.2	2.0	2.6	1.4	2.1	2.7	2.1	1.5	1.3
Pb	123	87	93	77	16	143	2	3	9	73	106
Th	41	64	73	63	74	44	56	91	19	24	34
U	21	18	19	13	48	16	49	40	38	7	17
W	7	16	12	50	13	16	16	7	12	5	8
La	32.41	45.00	60.77	45.33	35.80	29.63	31.40	19.39	7.42	8.52	10.04
Ce	57.48	81.13	108.0	86.83	67.70	50.84	56.90	36.28	16.20	16.90	18.77
Pr	6.37	10.09	12.23	9.58	7.80	5.31	6.20	4.19	2.10	1.80	2.13
Nd	32.39	36.43	48.33	37.80	29.9	22.32	22.97	16.32	9.65	8.28	10.28
Sm	5.09	7.52	9.43	7.52	5.80	4.26	4.53	3.20	2.33	1.67	2.24
Eu	0.82	1.48	1.55	1.16	1.06	0.78	0.92	0.65	0.37	0.30	0.39
Gd	2.71	4.33	6.97	5.30	3.65	2.79	3.70	2.25	1.37	1.03	1.68
Tb	0.47	0.73	0.78	0.67	0.47	0.46	0.59	0.27	0.19	0.15	0.21
Dy	2.14	3.85	4.26	3.53	2.58	2.27	3.69	1.48	0.95	0.98	0.93
Ho	0.36	0.61	0.82	0.76	0.47	0.51	0.70	0.32	0.21	0.20	0.25
Er	1.12	1.80	2.08	1.89	1.31	1.38	1.99	0.83	0.55	0.48	0.68
Tm	0.18	0.41	0.31	0.26	0.20	0.20	0.34	0.13	0.09	0.09	0.08
Yb	1.15	2.03	2.03	2.13	1.37	1.68	2.12	0.92	0.53	0.81	0.69
Lu	0.19	0.33	0.34	0.31	0.22	0.23	0.34	0.12	0.10	0.08	0.16
Eu*	0.68	0.79	0.59	0.56	0.71	0.69	0.69	0.74	0.63	0.71	0.62
ΣREE	143	196	258	203	158	123	136	86	42	41	49

Trace elements are analysed by LA-ICP

chemistry, as A/CNK parameter is usually below 1. Only in altered and weathered samples it weakly exceeds 1.1 and appears normative corundum (Table 5.1). In both plutons mafic minerals are amphibole and biotite; common accessories are allanite and titanite. The plutonic rocks possess sharp, discordant contacts with hosting high-grade metamorphic rocks. Mafic magmatic enclaves can be found in Lutskan pluton, attesting that more mafic magma also was implicated in its differentiation. Distribution of elements on Harker-type diagram generally present linear variations (Fig. 2). All these features are consistent with I–type granitoid classification (Pitcher, 1993).

Hf isotope data from zircons yield ambiguous results: εHf ranges from +2.6 to +0.6 in sample 11aTr (granodiorite), where important 540 Ma inheritance in the zircon core was established (Dyulgerov et al., 2006; Peytcheva et al., 2009). This mixed crust-mantle signature probably reflects the presence of older material, participated in the petrogenesis in the granitoids. Or, at least, similar material was assimilated by granitic magma during its formation, ascent or emplacement. Dominantly crustal characteristic was obtained in zircons from sample 12Tr granitic dyke, where εHf is between –3.4 and –10.1 (Dyulgerov et al., 2006). We interpret the result from 12Tr as representative for derivation of the parental for Lutskan pluton magma from crustal precursor, as the negative εHf could also indicate terrigenous input in the source region. Isotopic study of Zagorchev and Moorbath (1988) does not re-

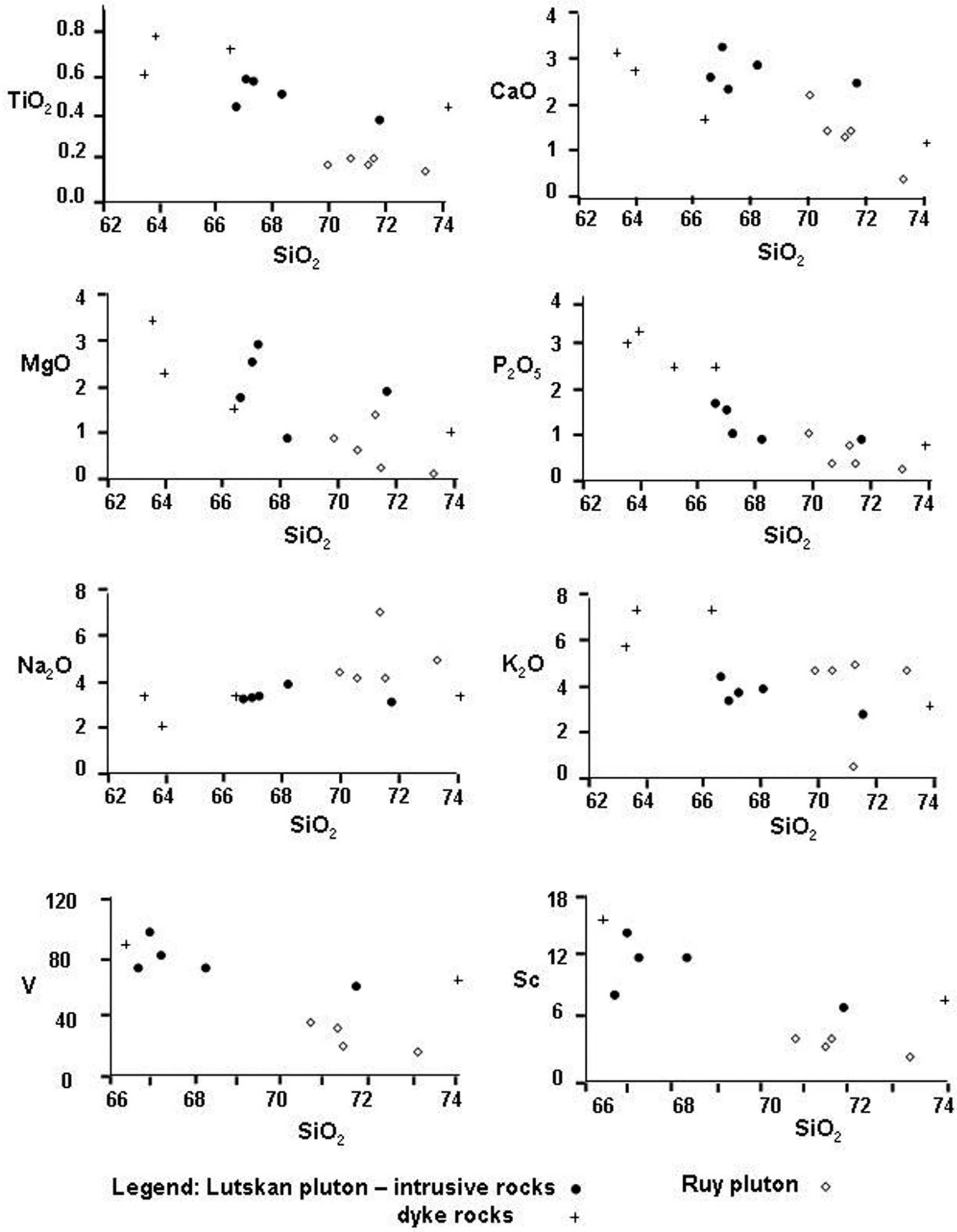

Fig. 2. Harker diagrams for the rocks from Lutskan and Ruy plutons

Фиг. 2. Харкерови диаграми за скалите от Люцканския и Руйския плутон

spond unequivocally on the source of the Lutskan pluton. Their results for Sr_i recalculated on 330 Ma are between 0.7072 and 0.7078 for granitoids, and 0.708 for the alkaline dykes. These data are in favour of the crustal or mixed crustal-mantle origin of the plutonic rocks, but do not imply on the dominance of sedimentary material in the protolith. The important Sr and LREE contents from the other hand preclude involvement of pelitic sediments in the source region. The very high enrichment level of some highly incompatible elements as Rb, Cs, Ba, Pb, Th, U, Nb, REE and the isotope data are in favour of derivation via melting of mixed igneous plus sedimentary materials. But the enrichment level of these elements far exceeds the

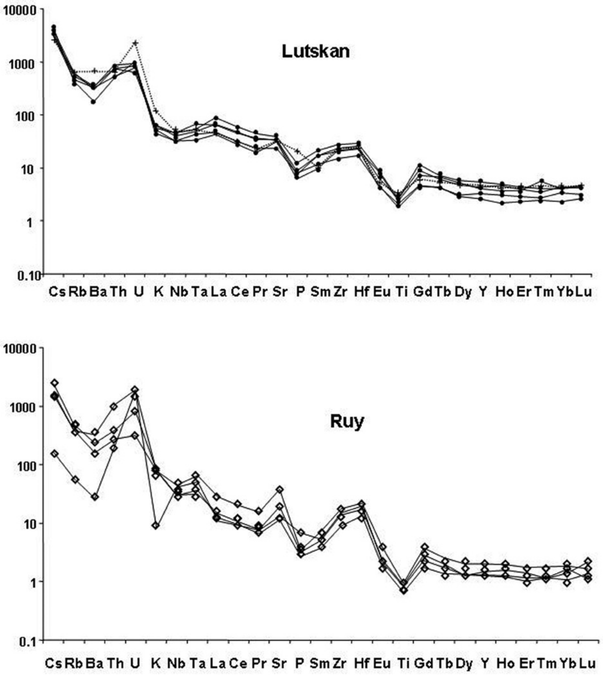

Fig. 3. Multicomponent diagrams (spidergrams) for the rocks from Lutskan and Ruy plutons
Normalization on Primordial Mantle according to Sun and McDonough (1989)

Фиг. 3. Многокомпонентна диаграма (спайдердиаграма) за скалите от Люцканския и Руйския плутон
Нормиране по примитивна мантия на Sun and McDonough (1989)

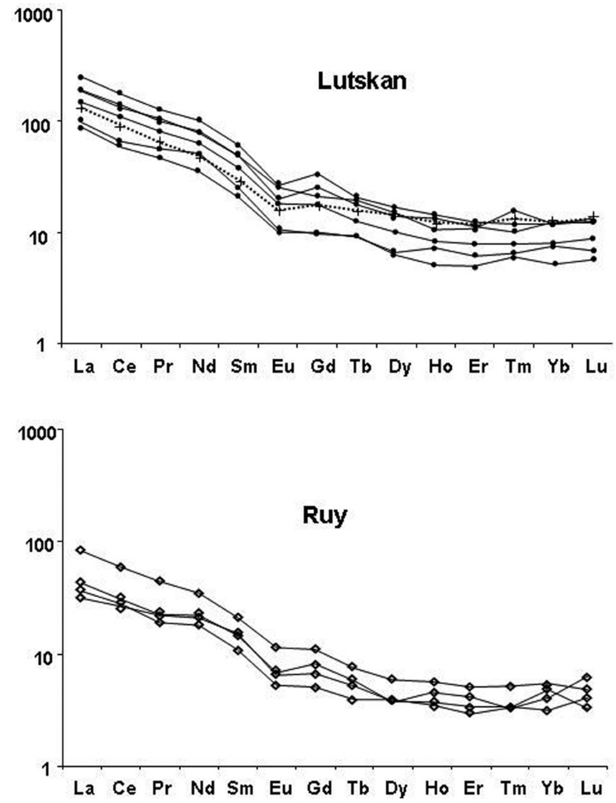

Fig. 4. REE distribution in the rocks from Lutskan and Ruy plutons
Normalization on Chondrite C1 according to Sun and McDonough (1989)

Фиг. 4. Разпределение на РЗЕ в скалите от Люцканския и Руйския плутон
Нормиране по Хондрит С1 на Sun and McDonough (1989)

content of these elements in all known Upper Crustal reservoirs. Thus, we consider that igneous protolith, implicated in the petrogenesis in Lutskan and Ruy plutons, experienced substantial enrichment during previous subduction/collision episodes (Fig. 5).

Geodynamic setting and correlation with other Variscan granitoids

The existing tectonic reconstructions of the Variscan evolution in Bulgaria are focused on Western Stara Planina and Srednogorie granitoids (Haydoutov, 1991; Haydoutov, Yanev, 1997; Carrigan et al., 2005) and do not threat Lutskan and Ruy plutons from Kraishte zone. The chemical particularities of the rocks of Lutskan and Ruy plutons without doubt imply on their orogenic character: weak negative anomalies in Nb, Ta and Ti and steep slope on the spiderdiagram (Fig. 3). The important enrichment in LILE elements are in favour of formation in postcollisional setting. The granitic plutons have not experienced any deformation, so their emplacement was posterior to the main collision events.

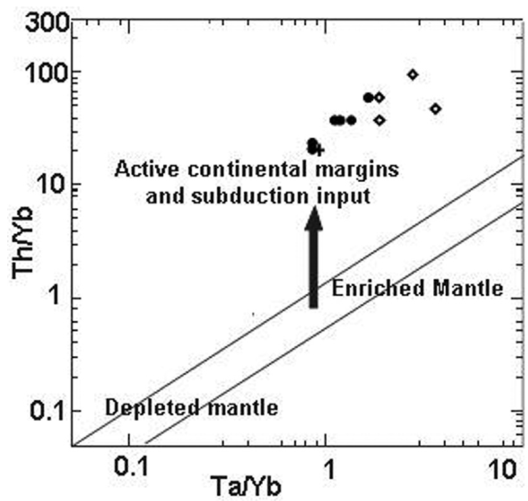

Fig. 5. Ta/Yb vs. Th/Yb diagram (Pearce, 1982) for the rocks from Lutskan and Ruy plutons
Symbols as in Fig. 2

Фиг. 5. Ta/Yb vs. Th/Yb диаграма (Pearce, 1982) за скалите от Люцканския и Руйския плутон
Символите са като на фиг. 2

Lutskan and Ruy plutons represent small isolated fragment of the Variscan edifice in Western Bulgaria. The relationships of these plutons with the other Upper Palaeozoic igneous rocks, outcropping in Western and Central Stara Planina, are generally unknown. Emplacement of all magmatic bodies is in a narrow period of time span (Kamenov et al., 2002; Carrigan et al., 2005; Dyulgerov et al., 2007), thus they belong to one tectonic event.

In the group of Variscan magmatic bodies several rock types can be outlined. To the first group belongs I-type granitoids, which modal composition varies from granodiorite to monzogranite. These are Vezhen, Hisara, Smilovene, Petrohan, Sv. Nikola and Stakevtsi plutons. The second can be assigned to S-type leucogranites – Koprivshtitsa, Klisura, Strelcha plutons. The third group comprises small potassic-alkaline monzonites and syenites – Svidnya, Buhovo–Seslavtsi and Shipka plutons (Dyulgerov, 2005). The modal composition of Lutskan and Ruy place these plutons in the group of I-type granitoids. They have metaluminous character, granodiorite–monzogranite species dominate, and contain mafic enclaves (like Petrohan and Vezhen plutons). But the geochemistry of Ruy and especially Lutskan plutons markedly differs from those of the other I-type granitoids. Several differences can be outlined: contents of LIL elements in Lutskan and Ruy plutons exceed 2–3 times (for Ba 4–5 times) those established in other Variscan granitoids (Boyadjiev, 1991; Kamenov et al., 2002; Machev et al., unpubl. data; Peytcheva et al., unpubl. data). Some strongly incompatible HFSE like Th (40–90 ppm), U (15–40 ppm) and Nb (20–35 ppm) also present very high levels of enrichment (Fig. 4), as similar values for these elements are known only from Svidnya, Buhovo-Seslavtsi and Shipka plutons (potassic-alkaline association). REE contents in Lutskan pluton (between 130 and 260 ppm) are higher than those established in other calc-alkaline granitoids and indicate enrichment event of the source, which can not be attained by simple assimilation of sediment (or any other crustal) material.

All discussed geochemical particularities of Tran granitoids attest that these plutons show resemblance with the rocks of potassic-alkaline association: high contents of LILE, Th, U, Nb, Ta, and REE (for Lutskan pluton). These common geochemical features imply on the fact that the both associations have cognate source. Or, at least, these rocks originate from a source with common in some aspects tectono-magmatic evolution.

Dyulgerov (2005, 2008) and Dyulgerov et al. (2007) based on isotope and trace elements, proposed an enriched mantle source (EM II) for potassic-alkaline rocks from Stara Planina. Enrichment, which occurred during previous orogenic/subduction episodes, added to the mantle incompatible LILE and HFSE, radiogenic Sr and unradiogenic Nd signature.

The existing data do not support direct mantel origin of the Lutskan and Ruy plutons. The granites do not associate with more mafic rocks and they can not be regarded as a residual liquid from more primitive magma. Moreover, their isotope characteristics do not indicate involvement of significant mantel components in their petrogenesis. Thus, we consider that granites were generated at crustal level, but materials implicated in their petrogenesis were modified via subduction/collision events. This model explains the substantial enrichment in LILE, Th, U and LREE (also called hygromagmatofile elements). These elements are relatively mobile and easily transported by fluids. Thus, slab dehydration during previous subduction/collision events, could add these elements to the source region. Any further melting episode will mobilise hygromagmatofile elements and produced magmas will show LILE, Th, U and LREE enrichment.

Final remarks

On the basis of performed field and geochemical studies several conclusions can be outlined:

1. Lutzkan and Ruy plutons are postcollisional bodies and their petrographic and major element compositions place these plutons amid the I-type granitoids (Vezhen, Hisara, Smilovene, Petrohan, Sv. Nikola and Stakevtsi).

2. The petrography of both plutons characterizes with one monzogranite/granodiorite phase followed up by more leucocrate aplitoide granite.

3. In the petrogenesis of Lutskan pluton participated more heterogeneous material – processes of mixing with more primitive magmas are evidenced by the presence of MME. This resulted in more important amount of mafic minerals and higher TiO_2, FeO, MgO, MnO, CaO, P_2O_5 contents in Lutskan pluton compared to Ruy one.

4. The significant enrichment in incompatible trace elements Rb, Ba, Sr, Th, U, Nb, LREE and emplacement of potassic-alkaline dyke residue in shows that Lutskan and Ruy plutons have distinct geochemical signature.

5. The Variscan magmatisma in Bulgaria (eastern part of the Variscan orogen) is generated from heterogeneous sources. This is evidenced by the presence of variable products of the magmatic activity: S- and I-type granitoids, potassic-alkaline monzonites and syenites, and finally Lutskan and Ruy plutons. These two plutons occupy specific position in the Variscan edifice in Bulgaria – their whole-rocks chemistry is indistinguishable from the other calc-alkaline granitoids, but trace elements enrichment place Lutskan and Ruy plutons in the group of magmatic rocks that originate from enriched/modified source.

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