Eastern Srednogorie zone – new geochemical data for lateral zonation of magmatism

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Introduction and geological background

The Eastern Srednogorie zone represents the easternmost part of a narrow 1500 km long belt of Upper Cretaceous calc-alkaline magmatic rocks in the Carpathian-Balkan region of the SE Europe. The belt contains the major porphyry-coper deposits in Europe and is known as Banatitic Magmatic and Metallogenic Belt (Berza et al., 1998) or Apuseni-Banat-Timok-Srednogorie belt (ABTS, Popov, Popov, 2000). Its tectonic evolution broadly relates to subduction processes prior to the Late Cretaceous collision events (Ciobanu et al., 2002), but the complex regional geodynamic evolution is not well reconstructed. One of the main reasons for this is the absence of sufficient petrological, geochronolical and isotope data for the magmatic rocks. Up-to-date research is being done for the Central Srednogorie zone of the ABTS belt (von Quadt et al., 2005). Results obtained for the major magmatic centers of the zone show an across-arc north to south migration of magmatism with an increasing contribution of mantle-derived material in the same direction.

In this paper we turn special attention to the geochemistry of the magmatic rocks of the Eastern Srednogorie zone. Compared to the other parts of ABTS belt this zone has specific features in terms of tectonics, magmatism and metallogeny. It has the thinnest (27-30 km) crust and the most intensive positive gravity anomalies on the territory of the Balkan Peninsula (Georgiev et al., 2001). Magmatism is most abundant, with intrusive and volcanic rocks showing considerable compositional variation and basic to intermediate magmas predominating over felsic types. Based on the petrological characteristics of the rocks four magmatic regions are distinguished from south to north (Dabovski et al., 1991): Strandzha volcano-intrusive region (SVIR), Yambol-Burgas volcano-intrusive region (YBVIR), North Burgas volcanic region (NBVR) and Luda Kamchya volcanic region (LKVR) in the East Balkan (fig. 1). SVIR is intrusion-dominated. Upper Cretaceous gabbros, diorites and granites are intruded in Paleozoic granites as well as Paleozoic, Triassic and Jurassic metamorphic rocks. YBVIR consists of Upper Cretaceous sediments, volcanoclastics, lava flows and pillow lavas with total thickness of more than 5000 meters. The volcanic structures are of central and linear type. Basement is not exposed, nor is it reached in drill-cores. NBVR is a narrow strip of outcropping ultra-K pillow lavas, comprising volcanoes of linear type. LKVR is characterized by a minor igneous activity, mostly dikes and subvolcanic bodies intruding the Triassic and Jurassic metamorphosed sediments, and small remnants of lava flows.

The pre-existing geochemical data on the magmatism is mostly on the major element composition of the rocks. Most of the studies concern separate volcanic and/or intrusive centers in Eastern Srednogorie with only few papers summarizing the available data (Stanisheva-Vassileva, 1980; Georgiev et al., 2001). These studies point out the most characteristic features of the magmatism in Eastern Srednogorie: it is the most voluminous, basic and K-rich, compared to other parts of the ABTS belt. The authors emphasize the prominent trend of K_2O increase from south to north towards the continental hinterland.

In contrast to the numerous major element analyses of magmatic rocks published trace element data for the Eastern Srednogorie zone are very limited. Manetti et al. (1979) report the trace element content of 10 samples of the volcanic rocks from the CA and SH rocks in the YBVIR. Based on the distribution pattern of the REE the authors argue that the rocks are produced by various degree of melting of enriched mantle material (spinel peridotites and garnet peridotites), followed by crystal liquid fractionation of mainly olivine and some pyroxene and spinel. Stanisheva-Vassileva and Daieva (1990) turn

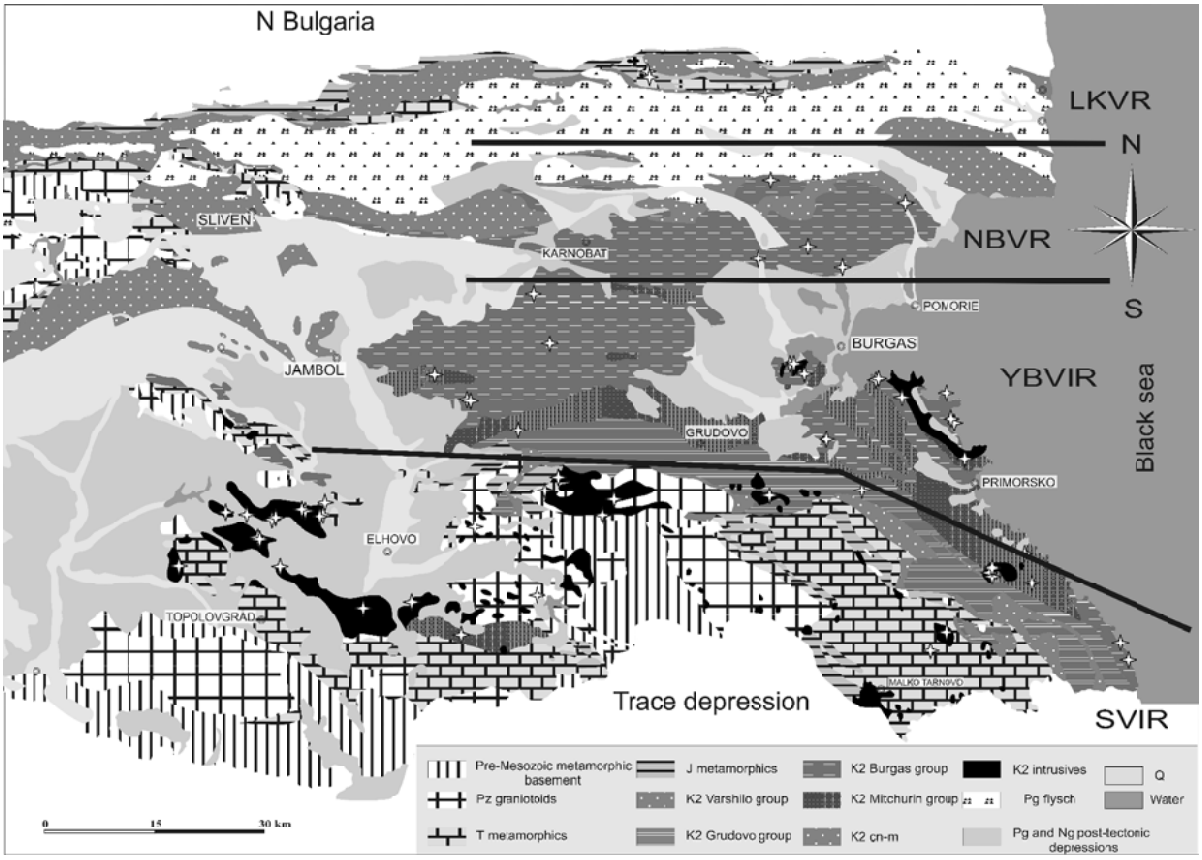


Fig. 1. Geological map of Eastern Srednogorie zone, modified after Cheshitev and Kancev, 1989. See text for abbreviations. Samples location shown.

special attention on the trace element contents and observe that from south (Strandzha) to north (Yambol-Burgas) the concentrations of K, Mg, Rb, Ba, Sr, Ni, Cr, Sc, Th, U, Zr, Hf, Ta, as well as the ratios K/Ti, Zr/Hf, Ba/Lu increase.

The prevailing model for the geodynamic evolution of the zone is a "triple arc structure" (Georgiev et al., 2001), consisting of a frontal arc (SVIR), central submarine volcanic arc (YBVIR) in the axial part of an intra-arc basin, and an incipient back-arc rift (NBVR). LKVR has not been incorporated in the model, because of lacking geochemical data.

The purpose of this study is to summarize the available major element data and to integrate them with our major and trace element analyses obtained for 70 samples from all 4 regions of the Eastern Srednogorie zone. In two other papers (Georgiev et al., 2005; 2006 in press) we discuss the preliminary U/Pb age data from zircons and their Hf isotope ratios. A future combining of the geochemical, precise geochronological and isotope data will help us to elucidate the complex geodynamic history of this zone.

Materials and methods

Samples for hole-rock major and trace elements determination were carefully selected to avoid hydrothermal alteration. Samples were finely crushed in the "Eurotest" laboratory, Sofia. Major elements were determined with XRF in the University Salzburg, Austria. Trace elements were determined with a LA-ICPMS on fused LiB_4 pellets in ETH-Zurich.

Results

From the 70 studied samples 31 are from SVIR, 25 from YBVIR, 10 from NBVR and only 4 from LKVR. The results are shown on fig. 2, together with the summarized published analyses by Georgiev et al. (2001). As can be seen from the TAS diagram (fig. 2a.), there is a wide variety of magmatic rocks in Eastern Srednogorie. Clearly visible is the difference in the alkali content between the southern, Strandzha region, and the YBVIR and NBVR. The trend of increasing alkali content is interrupted in the northernmost LKVR. When plotted on a potassium oxide against silica oxide diagram the rocks from SVIR and LKVR fall in the calc-alkaline field, with subordinate rocks belonging to the tholeiitic and high K-calk-alkaline series (fig. 2b). In contrast, the rocks from YBVIR and NBVIR belong mostly to the shoshonitic series. On a primitive mantle -normalized plot of the trace elements the rocks from the different regions show similar patterns, with enrichment in

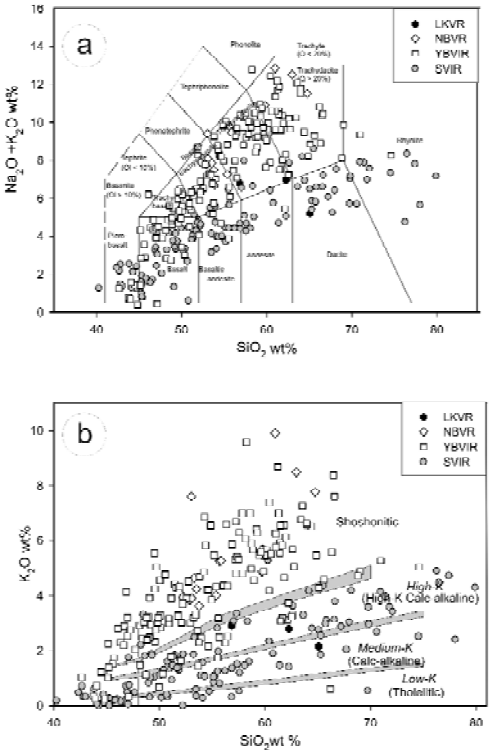


Fig. 2. Major element plots for new and published analyses from Eastern Srednogorie zone. a) TAS diagram; b) K_2O-SiO_2 diagram

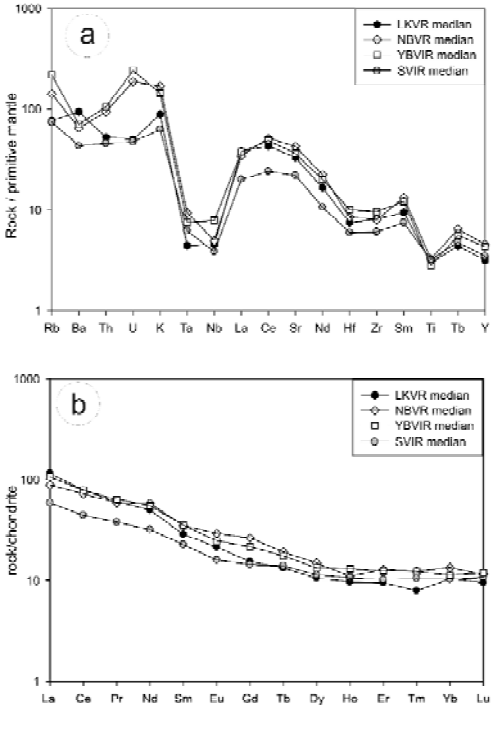


Fig. 3. a) Median values of the (a) primordial mantle normalized trace elements patterns and (b) the chondrite normalized REE patterns for the four main regions in Eastern Srednogorie

large ion lithophile elements(LILE) and low values of the of high field strength elements (HFSE), and a pronounced Nb-Ta trough (fig. 3a). Although the rocks display similar patterns, it should be noted that the rocks from YBVIR and NBVR are characterized by far more extreme enrichment in incompatible trace elements, particularly Rb, Th, U Sr and LREE (fig. 3a and 3b). The other notable features are the relatively flat pattern of the heavy REE and the absence of, or very weak Eu anomaly. The degree of REE enrichment (the ratio of normalized La versus Yb) changes from 5.8 in Strandzha, to 8.4 in Yambol and North Burgas and increases further in Luda Kamchya region to 10.4.

Discussion and conclusions

In terms of major element composition the great diversity of the rocks in the Eastern Srednogorie zone is the most prominent feature. Basic magmatic products predominate and the rocks are enriched in K_2O. When subdivided according to their K_2O content (fig. 2a and b), clearly there are two major regions: SVIR to the south, and YBVIR and NBVIR regions north of it. This is interpreted as representing different degrees of partial melting of a comparatively similar mantle source. The idea is supported by the different degree of enrichment in LILE and LREE in both regions (fig. 3a and b). The enrichment in LILE, relative depletion of HFSE, and the pronounced Nb-Ta trough (fig. 3a) all suggest a subduction-related origin for the magmatic rocks in the zone. The magmas did not fractionate significant amount of plagioclase, which is reflected in the absence of a negative Eu anomaly.

The zoning in K_2O content, as well as the increase of LILE and LREE, is interrupted, when we include the samples from the northernmost region, the LKVR. In terms of their total alkali content, as well as the K_2O content only, the rocks from LKVR appear to be more similar to the SVIR. The K_2O to Na_2O ratio also follows the same path and changes from about 0.5 in the south to 1.2 in Yambol-Burgas and N Burgas regions and then drops again to 0.7 in LKVR. The rocks from the last region are more similar to the SVIR in terms of their trace element content.

Precise U/Pb age dating and isotope tracing of the magmatism accompanied by major- and trace element data and mineral composition studies will be used for better understanding of the complex geodynamic history of this zone.

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Източносредногорската зона — нови геохимични данни за латерална зоналност на магматизма

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Резюме. Източно-Средногорската зона е част от магматичния и металогенен пояс Апусени-Банат-Тимок-Средногорие (АБТС). В сравнение с останалите части на АБТС, Алпийският магматизмът в нея се отличава с голяма интензивност и разнообразие. Въз основа най-вече на геохимичните особености на скалите в Източното Средногорие от юг на север могат да бъдат разграничени четири региона: Странджански вулкано-интрузивен, Ямболско-Бургаски вулкано-интрузивен, Севернобургаски вулкански и Лудокамчийски вулкански. В настоящата работа обобщаваме наличната публикувана информация за състава на скалите и представяме графично нови данни за главните елементи и елементите-следи на нови 70 проби от четирите региона. Резултатите показват, че скалите от всички зони имат субдукционен характер. Съдържанието на калий и на несъвместимите елементи-следи в скалите се увеличава от юг на север. Тази зоналност се нарушава в региона на Лудокамчийския регион, който по своите геохимични характеристики е по-близък до Странджанския вулкано-интрузивен регион. Допълнителни възрастови и изотопни определения са необходими за изграждане на успешен геодинамичен модел за еволюцията на Източното Средногорие.