

KALOFER GRANITOID SUITE. A LATE VARISCAN STITCHING PLUTON

Ianko Gerdjikov, Eleonora Balkanska

(Submitted by Corresponding Member I. Zagorchev on January 15, 2013)

Abstract

Two contrasting Variscan units are juxtaposed in the area of Central Stara Planina Mountain. They are represented by two metamorphic complexes: a high-grade (Central Srednogorie high-grade metamorphic complex – CSHGMC) and low-grade (Stara Planina low-grade metamorphic complex – SPLGMC). Unlike the area to the west (Zlatitsa Stara Planina Mountain), the contact between them is severely overprinted by Palaeocene–Eocene thick-skinned thrusting and Miocene–Quaternary extension. The suturing/docking of the two units is well constrained as Visean (~ 330 Ma) and after a gap of about 15–20 Ma voluminous batches of granite magma were emplaced into the SPLGMC. These granites (Karlovo–Ribaritsa suite) are almost everywhere intensively foliated and they delineate a Late Variscan strike-slip dominated tectonic belt. As a contrast, another widespread granitoid suite (Kalofer granitoids) does not display gneissic fabric and can be regarded as a part of the batholithic-scale, composite Hisarya–Pastrovo pluton (303 ± 3 Ma). Our study documented contacts of the Kalofer granitoid suite, the type of the internal fabric and the presence of inclusions. The perfectly outcropped Palaeogene Botev Vrah allochthon is built by a sill-like body of Kalofer granitoids, emplaced conformably into SPLGMC. These granitoids are foliated along their margins as well as in shear zones. Despite this solid-state overprint, numerous meso-scale features indicate intrusive relations. On the other hand, it is well known that Kalofer granitoids are intrusive into CSHGMC gneisses and they also contain

The work on this paper was initiated during the realization of PhD project (Eleonora Balkanska) funded by grant VU-13/06 from the Bulgarian National Science Fund (NSF). Additional support was provided by another NSF grant (DMU-03/41).

km-scale stopped blocks/rafts from them. These relations undoubtedly indicate that the composite Hisarya–Pastrovo pluton is stitching one of the most important Variscan contacts in the central part of the Balkan peninsula.

Key words: Kalofer granitoids, Late Variscan magmatism, stitching pluton, Central Stara Planina Mountain

Introduction. Granitoid magmatism is a common feature of the Variscan orogenic belt and it is well recognized in the Balkanides (e.g. [1]). In recent years, the geochronological data have given precise constraints of the timing of the variously sized plutons [2]. For the moment, there is an obvious lack of modern structural data that can put constraints on the tectonic setting and emplacement mechanisms of these plutons.

Recently we have proposed a new model [3] for the stratigraphy of the pre-Permian basement in Central Stara Planina Mountain (between Troyan Pass and Mazalat Summit) and on this basis we have studied in some details the contacts and relations between different basement units and the distinct groups of granitoid plutons. The aim of this contribution is to give new data on the composition, structure and emplacement mechanism of Kalofer granitoids [4] that build the allochthon of Botev Vrah Thrust. It is well known that these granitoids are part of the batholithic-scale composite pluton cropping out in Sredna Gora Mountain. Based on the field relations with the host rocks, mineralogy and fabric, we refer to this huge magmatic body as Hisarya–Pastrovo pluton (Fig. 1). These new data are discussed in the light of the preliminary geochronological data and as a result a new geodynamic model is suggested. When describing the structures in the plutons, we adopt the terminology of PATERSON et al. [5] for magmatic stopping, rafts and stopped blocks.

Late Alpine tectonic frame. Central Stara Planina Mountain is a classical locus for Late Alpine Thrust tectonics. It is well known that the pre-Permian basement was emplaced onto Upper Cretaceous and Palaeogene sediments (Botev Vrah Thrust) [6]. Our recent re-examination of the thrust has allowed to disprove some of the deeply rooted conjectures existing in literature: 1) the emplacement of the thrust occurred in the upper parts of the crust and the associated tectonites are low-temperature ones (below 200–150 °C). Therefore, we cannot confirm the suggestions for extensive mylonitization at the base of the allochthon [7,8]; 2) since Botev Vrah allochthon is a thick-skinned thrust, it is futile to discuss the root zone [9]. As a consequence, we regard all rocks above the thrust (the large klippen at the crest of the mountain, the several small fault-bounded basement pieces at the southern foot of the mountain and the basement rocks to the south) as parts of the thrust. Thus we suggest the existence of a large, single thrust plate that indeed in the areas of the Miocene–Quaternary grabens was displaced/tilted due to the slip along a system of normal faults (e.g. [10]); 3) our mapping and structural analyses do not confirm the existence of two independent Late Alpine Thrust

systems – Karlovo (Shipka) and Stara Planina Granite Thrusts [4,8]. Instead, in line with the ideas of CHESHITEV [6], a single thrust model is preferred. Local complications of the thrust zone do exist and most often they are represented by dm-scale imbricate structures occurring along the southern foot of Stara Planina Mountain. Only one imbricate structure was mapped within the large klippen, where a small sandwiched piece of Upper Cretaceous limestones was found [11].

In summary, all data are consistent with the idea that Botev Vrah allochthon is a well-outcropped and well-preserved vestige of the Variscan orogen.

New data for the basement structure and tectonics in Central Stara Planina Mountain. On the basis of our mapping and structural analysis, we outline the following key features of the pre-Permian basement:

Within the pre-Permian basement, two main metamorphic complexes/units can be distinguished. The first one is cropping out only in Stara Planina Mountain and is poorly known in terms of stratigraphy and thickness. It represents dominantly a metasedimentary sequence that consists of metapelites, metaaleurolites with minor quartzites, tuffs and metabasic bodies. On the basis of regional correlations, a Lower Palaeozoic age (Cambrian–Silurian) is assumed. The metamorphic grade is lowermost greenschist facies with local domains displaying higher peak temperatures (biotite isograd). A specific and until recently unrecognized suite of granitoids is a part of this complex – the Ambaritsa meta-granites [3] – a suite of fine-grained, leucocratic granitoids that display intimate and interfingering relations with the metasedimentary sequence. Being well aware of the problems with used nomenclature (including the obsolete term Diabase–Phyllitoid Complex and subdivision applied for NW Bulgaria), we refer to this complex as Stara Planina low-grade metamorphic complex (SPLGMC). Another granite suite is spatially related to the occurrences of SPLGMC and displays evidence for extensive solid-state overprint. Karlovo–Ribaritsa granites [3] are medium-grained, most often leucocratic, even-grained to plagioclase or K-feldspar porphyritic. They form strongly elongated bodies that are emplaced as decimetre to km-scale sill-like conformable bodies into the rocks of SPLGMC. Almost invariably they are intensively foliated. Crystallization age (by U-Pb method of zircon grains) of Karlovo–Ribaritsa granites is not yet sufficiently precise, nevertheless, their age is beyond any doubt Late Variscan [11,12]. It is also clear that this plutonism was accompanied by strike-slip dominated ductile deformation that affected strongly the rocks of SPLGMC.

The second metamorphic complex represents a part of the hot core of the Variscan orogen and is characterized by polycyclic evolution. It consists mainly of migmatitic paragneisses with minor amphibolites and orthogneisses (Central Srednogorie high-grade metamorphic complex – CSHGMC). These rocks record classical orogenic metamorphic evolution with earlier HP stage [13] and peak temperature stage at ~ 336 Ma [14] followed by often penetrative greenschist overprint related to exhumation stage.

Kalofer granitoid suite (KGS) is a composite, nested intrusion composed by a number of texturally and petrographically different phases that range in composition from diorite, granodiorite, granite to leucogranite. The name Kalofer granites was coined by the authors of the first detailed geological map of Central Stara Planina Mountain [4]. Under this name intrusive rocks with wide range of composition are designated. In fact, in terms of mineralogy and texture, they are indistinguishable from the granitoids of Hisarya–Pastrovo pluton that crop out in the basement of Karlovo and Sheynovo grabens and in Sredna Gora Mountain. The most prominent features of the Hisarya–Pastrovo pluton as wide range in composition, abundance of magmatic inclusions, rafts and roof pendants are well-known [15,16].

Unlike the well-studied main part of the Hisarya–Pastrovo pluton, the KGS from Botev Vrah allochthon is poorly known. The main part of this composite body is made up of megacrystic granitoid phase that contains medium- to coarse-grained K-feldspars (up to 2–3 cm). Another regionally extensive phase crops out on the main crest and along the northern slopes of the mountain, just west of Botev Summit. This is a medium- to coarse-grained dark grey hornblende-bearing phase called Zhaltets granodiorite [11]. More mafic varieties (probably of dioritic composition) are rarely found as decimetric bodies, especially in contact zones that display evidence for magmatic sheeting. Fine-grained aplitic or leucogranitic dykes and rarely stockworks are ubiquitous and abundant especially close to the contacts of the granitoids. The latest intrusive phases consist of medium-grained leucogranites and granodiorites (hornblende-bearing) that form metre-km scale bodies with irregular shapes.

The granitoids from KGS display complex relations with different types of host rocks. It is widely assumed that KGS is intrusive only into the CSHGMC gneisses. This supposition is based on well-documented relations in the areas of Karlovo, Kalofer and further south in Sredna Gora Mountain [15,16]. Field as well as geochronological data [2] clearly indicate that the emplacement of Kalofer granitoids was well after the high-grade metamorphism of CSHGMC rocks.

To gain well-constrained knowledge of the pre-Permian and Late Alpine tectonics, it is important to study in detail the relations of Kalofer granitoids with the various rocks from SPLGMC. That is why we mapped in detail the contacts of KGS on the southern slopes and crest area of Stara Planina Mountain and our data suggest a rather different picture from the model suggested by [4]. First, N and NE of Sopot, we mapped a body of coarse-grained, containing pinkish K-feldspar, megacryst granites that display intrusive relations with the low-grade metasedimentary sequence and Ambaritsa metagranitoids. Despite the probably km-scale displacement by the graben-bounding normal fault, this granite is connected to the similar plutonic rocks that build the basement of Karlovo graben. On the basis of these spatial relations, mineralogy and textural features, as well

as weak solid-state overprint, we suggest that this body is part of KGS. Key data were also gathered as a result of the study of the large klippe of Botev Vrah allochthon (close to the ridge of Stara Planina Mountain, between the peaks of Golyam Kuppen and Botev). Here, the granitoids from KGS display complex, but nevertheless unambiguous intrusive relations with the rocks of the SPLGMC (Fig. 2a, b). The complex nature of the contact is a result of two phenomena: 1) intensive ductile deformation (Fig. 2c, d); 2) magmatic sheeting that resulted in complex mixing of the host rocks and the granitoids (Fig. 2e, f). Due to that most often the contacts of the Kalofer granitoids represent ca. 10–100 m thick zones of ductile deformation. Their detailed description is beyond the scope of this paper.

The KGS host a variety of inclusions, some of them with km-scale.

A salient feature of Hisarya–Pastrovo pluton is that the granitoids host different types of inclusions. Some of them are mafic microgranular enclaves (common in the area of Kalofer, and also east of the villages of Gorni Domlyan and Domlyan), but the typical ones are xenoliths from CSHGMC. Their size varies from metre to km-scale. Following the terminology of PATERSON et al. [5], most of them can be classified as stopped blocks. Importantly, large stopped blocks from CSHGMC exist in Kalofer granitoids that crop out in the large klippen, at the crest of Stara Planina Mountain, in the area west of Botev Summit (Fig. 3). The crystalline basement outcrops between Kalofer and the village of Vasil Levski are spectacular examples of km-scale rafts or roof pendants.

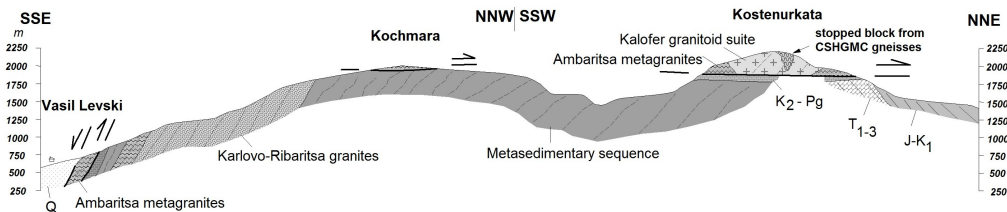


Fig. 3. Generalized cross-section along line I-I given in Fig. 1

The internal fabric of KGS mainly reflects the regional tectonic field at the time of emplacement and cooling. The granitoids from KGS display strikingly different fabrics. The latest magmatic pulses (fine-grained leucogranites, granodiorites, etc.) are isotropic. Also, there are domains, usually away from the contacts, where the granitoids show no macroscopic fabric, despite the presence of euhedral K-feldspar phenocrysts. This implies that the magmatic fabric is poorly expressed and also suggests a lack of sub-solidus deformation. On the other hand, there are numerous domains where solid-state overprint is intensive and rocks are transformed into mylonites and ultramylonites. Most often the K-feldspar megacrystic phase of the KGS displays such overprint in the contact zones and in various metre-decimetre-scale shear zones. Usually the foliation is

E-W trending, dipping shallowly to the south, and bears down-dip lineation. Except for a few not well defined sigma porphyroclasts recording top-to-the north shear sense (in the area north of the village of Tazha), unambiguous kinematic indicators were not observed. The trajectories of the foliation are not conformable to the pluton boundaries; instead in a number of places (between the peaks of Golyam Kupen and Kostenurkata, N of Kalofer) the foliation is orthogonal to the main trend of the contacts with the host rocks. This implies that the structures within the KGS are a result of a regional stress field at the time closely after the final solidification of the granitoids.

Geodynamic model for the late evolution stages of the Variscan belt in the Central Balkanides. Despite the often severe Alpine overprint, it is still possible to map and study in detail the major Variscan contact and various tectonic elements in the central part of the Balkan Peninsula. For Zlatitsa Stara Planina Mountain (west of the current study area), recently we reported the existence of the Stargel–Bolvania tectonic zone – a crustal-scale zone that emplaces/juxtaposes CSHGMC over the SPLGMC. On the basis of geochronological data, the age of the shearing is well constrained (~ 330 Ma) [14]. In the studied area, the contact between these different basement complexes is reworked by Late Alpine thrusting. Nevertheless, some inferences can be made: 1) For the moment there are no data that suggest that the age of the suturing/docking between the two basement complexes is different from the age obtained for the area westward; 2) The emplacement of Karlovo–Ribaritsa granite suite is not synchronous to the suturing of the two complexes, but it is some 10–15 Ma posterior to it. The new geochronological data (313–306) [11,12] actually invalidate our earlier supposition that these granites are synkinematic and emplaced along the contact of the CSHGMC and SPLGMC. Instead, now it appears that the emplacement of Karlovo–Ribaritsa suite was controlled by a Late Variscan strike-slip dominated tectonic belt developed completely within the upper structural levels of SPLGMC, close to the primary contact with CSHGMC; 3) The emplacement of KGS was synchronous to the last increments of Variscan ductile shearing. This latest granitoid suite, at least the part from the klippen in Central Stara Planina Mountain, records significant solid-state overprint. Field relations document protracted construction of the composite, nested intrusive body that displays intrusive relations with both metamorphic complexes. On this basis, we regard Kalofer granitoids as late synkinematic stitching pluton, emplaced probably in a local extensional domain at the closing stages of Variscan orogeny.

Conclusions. In summary, the rock associations and their relationships described here indicate that in this part of Stara Planina Mountain there is no direct contact between two metamorphic complexes different in terms of age, lithology, deformational and metamorphic evolution. The contact zone was stitched by distinctive phases of a composite granitoid pluton of Late Variscan age (~ 303 Ma). Structural data give evidence for prolonged granitoid emplacement in still hot

and actively deforming host rocks. The solid-state overprint argues for the importance of regional tectonics for creating space for pluton emplacement. Due to the lack of pronounced shear-sense indicators, the specific setting of pluton emplacement is difficult to constrain. It could be speculated that the KGS was emplaced in a local extensional domain. Also, several features (sharp discordant contacts with CSHGMC, lack of pluton-related ductile deformation, presence of xenoliths) strongly suggest the importance of magmatic stoping for the emplacement of KGS.

Acknowledgements. We are grateful to Dimo Dimov, Stoyan Georgiev, Kamen Bonev and Anna Lazarova for the assistance with field work and fruitful discussions.

REFERENCES

- [1] DIMITROV S. Ann. Sof. Uni., Phys.-Math. Fac., **35**, 1939, No 3, 225–253 (in Bulgarian).
- [2] CARRIGAN C. W., S. W. MUKASA, I. HAYDOUTOV, K. KOLCHEVA. Lithos, **82**, 2005, No 1, 125–147.
- [3] GERDJKOV I., A. LAZAROVA, E. BALKANSKA, K. BONEV, D. VANGELOV, D. DIMOV, A. KOUNOV. Compt. rend. Acad. bulg. Sci., **63**, 2010, No 1, 1169–1176.
- [4] MILANOV L., S. KUYKIN, I. GERCHEVA, S. CHRISTOV, V. KUNEVA. Jub. Ann., **18**, 1971, No 1, 199–221 (in Bulgarian).
- [5] PATERSON S. R., D. G. S. PIGNOTTA, D. FARRIS, V. MEMETI, R. B. MILLER, R. H. VERNON, J. ŽÁK. GSA Bulletin, **120**, 2008, Nos 7–8, 1075–1079.
- [6] CHESHITEV G. Ann. Direct. Gener. Rech. Geolog., **IX**, 1958, No 1, 1–27 (in Bulgarian).
- [7] BONCHEV E. Problems of Bulgarian geotectonics Sofia, Technika, 1971, 203 pp. (in Bulgarian).
- [8] BAKIROV A. B., M. BAC-MOSZASWILI, K. BREZSNYANSKY, E. A. GEORGIEV, P. S. PIRONKOV, I. SLAVKOVSKI, S. S. STOJANOV, Tz. V. TZANKOV, V. JAROSZEWSKY. Geotect., Tectonophys. and Geodyn., **17**, 1984, No 1, 3–34 (in Russian).
- [9] BALKANSKA E., I. GERDJKOV, D. VANGELOV, A. KOUNOV. Proc. of Int. Conf. “Geological Schools of Bulgaria. The School of Prof. Zhivko Ivanov”, 2012, 13–16.
- [10] TZANKOV Tz., D. ANGELOVA, R. NAKOV, B. C. BURCHFIELD, L. H. ROYDEN. Basin Research, **8**, 1996, No 1, 125–142.
- [11] BALKANSKA E. Structure and emplacement mechanisms of Botev Vrah Thrust, Central Stara Planina Mountain, Unpublished PhD Thesis, Sofia University, 2011, 237 pp. (in Bulgarian).
- [12] ANTONOV M., S. GERDJKOV, L. METODIEV, H. KISELINOV, V. SIRAKOV, V. VALEV. Explanatory note to the Geological map of Bulgaria in scale 1:50 000, Klisura map sheet. Consortium GeoComplex Ltd, 2010, 67 pp.
- [13] GAGGERO L., L. BUZZI, I. HAYDOUTOV, L. CORTESOGNO. Intern. J. of Earth Sci., **98**, 2008, No 8, 1853–1877.

- [¹⁴] CARRIGAN C., S. MUKASA, I. HAYDOUTOV, K. KOLCHEVA. *Precambr. Res.*, **147**, 2006, Nos 3–4, 404–416.
- [¹⁵] DABOVSKI CH., I. ZAGORCHEV, M. RUSEVA, D. CHUNEV. *Ann. UGP*, **16**, 1972, No 1, 57–92 (in Bulgarian).
- [¹⁶] ZAGORCHEV I., CH. DABOVSKI, D. CHUNEV. *Rev. Bulg. Geol. Soc.*, **34**, 1973, No 1, 1–10 (in Bulgarian).
- [¹⁷] IVANOV Z. In: *Guide to Excursion* (eds Z. Ivanov, T. Nikolov), Sofia, 1983, 326 pp. (in French).

St. Kl. Ohridski University of Sofia
15, Tsar Osvoboditel Blvd
1504 Sofia, Bulgaria
e-mail: janko@gea.uni-sofia.bg