Mylonitic Late Variscan granites from the central Balkan fold-thrust belt, Bulgaria

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Abstract: New structural and U–Pb zircon data from central Balkan fold-thrust belt reveal the existence of a zone of localized deformation confined mainly in the sheet-like Late Variscan Ambaritsa metagranites with crystallization age of 307.8±3.9 Ma. It is not well-established yet what were the relationships between the deformation and emplacement of the Ambaritsa intrusion. However, it could be suggested that both processes were tightly related and probably coeval, taking place during the latest stages of the Variscan compression as the deformation rests confined mainly in the Ambaritsa pluton and the later magmatic plutons in the study area are not affected by this specific deformation phase.

Introduction

The Balkan fold-thrust belt is considered as a retro-wedge in respect to the south-vergent internal units (i.e. Rhodope) of the Balkanide orogen confined between the Moesian platform to the north and the Vardar suture to the southwest (Fig. 1, e.g. Gochev 1991; Vangelov et al. 2013). Formed during the Mesozoic and Cenozoic, the belt preserves some vestiges of the Variscan orogen. The pre-Permian rocks, largely exposed in the western part of the Balkan fold-thrust belt, were more extensively studied (e.g. Haydoutov 1989; Plissart et al. 2017) in contrast to those in the central part of the belt, which have attracted less attention. Here we present structural and U–Pb LA-ICP-MS zircon data for a specific magmatic unit within the pre-Permian basement of the central parts of the Balkan ford-thrust belt revealing the development of a Late Variscan zone of localized deformation confined mainly in probably contemporaneous sheet-like intrusion.

Geological setting

In the central part of the Balkan fold-thrust belt two Variscan lithotectonic units (terranes) differing by its metamorphic grade as well as the lithologies and protolithic ages (Stara Planina low-grade metamorphic complex and Sredna Gora high-grade metamorphic complex) are juxtaposed. Their boundary is considered as a suture (Thracian and Balkan terrane, according to Haydoutov 1989 and Sredna Gora and Balkan terrane, according to Carrigan et al. 2005). More recent studies described this contact as a major ductile shear zone (Gerdjikov et al. 2007), often intruded by Late Variscan plutons (Gerdjikov & Balkanska 2013) and in places reactivated by an Alpine brittle thrust (e.g. Milanov et al. 1971; Balkanska & Gerdjikov 2010). This major boundary is cropping out in the western parts of the central Balkan fold-thrust belt (in Zlatitsa area) where the thrusting is dated at 333.9±0.2 Ma (D1 on Fig. 2, Gerdjikov et al. 2010a), shortly after the thermal peak of the metamorphism in the Sredna Gora metamorphic complex dated at about 337 Ma (Carrigan et al. 2006). However, in the study area, the thrust boundary is obscured by the voluminous Variscan granitoid magmatism (Gerdjikov et al. 2010b) and the later Alpine brittle to brittle-ductile compressional events, the most prominent of which is related to the formation of Botev Vrah thrust (Balkanska & Gerdjikov 2010). Common feature of the Stara Planina low-grade and Sredna Gora high-grade metamorphic complexes is the presence of abundant intrusive rocks ranging in composition from diorites to leucogranites. They are strongly deformed to undeformed and could be used as time markers delimiting different tectonic events. The Cambrian Karlovo granites (Fig. 2), representing the largest pluton intruding the Stara Planina low-grade metamorphic complex, are exposed in the southern parts of the study area.

Ambaritsa metagranites — main structural features and emplacement age

The Ambaritsa metagranites are largely exposed in the allochthon of the Late Alpine Botev Vrah thrust which occupies the Stara Planina Mountains crest. However, relatively large and elongated (up to 4 km) to small bodies intruded both the low-grade metamorphic complex and the Karlovo granites in the autochthon of the thrust.

These rocks represent a suite dominated by leucocratic fine-grained granites and minor diorites and granodiorites. The Ambaritsa metagranites are entirely recrystallized and overprinted by a strong fluid-assisted mylonitization. They are transformed in sericite or sericite-chlorite schists with a foliation defined by elongated quartz aggregates and align chlorite and sericite flakes. A greenschist facies deformation is well evidenced by the mineral association of sericite, chlorite, clay minerals, epidote, quartz and Fe-hydroxides, bulging recrystallization of quartz, feldspars replaced by sericite and clay minerals, “flame-shaped” perthites, etc.

Within the autochthon of the Botev Vrah thrust as well as in the allochthon relicts exposed along the footsteps of the Stara Planina Mountains the foliation is moderately dipping (30–60°) to the S and SW while the lineation, defined by chlorite, quartz and sericite is predominantly plunging towards SW or SE. The rocks form mainly S-type tectonites. At the Stara Planina Mountains crest, within Botev Vrah allochthon, the Ambaritsa metagranites form subhorizontal about 350 m

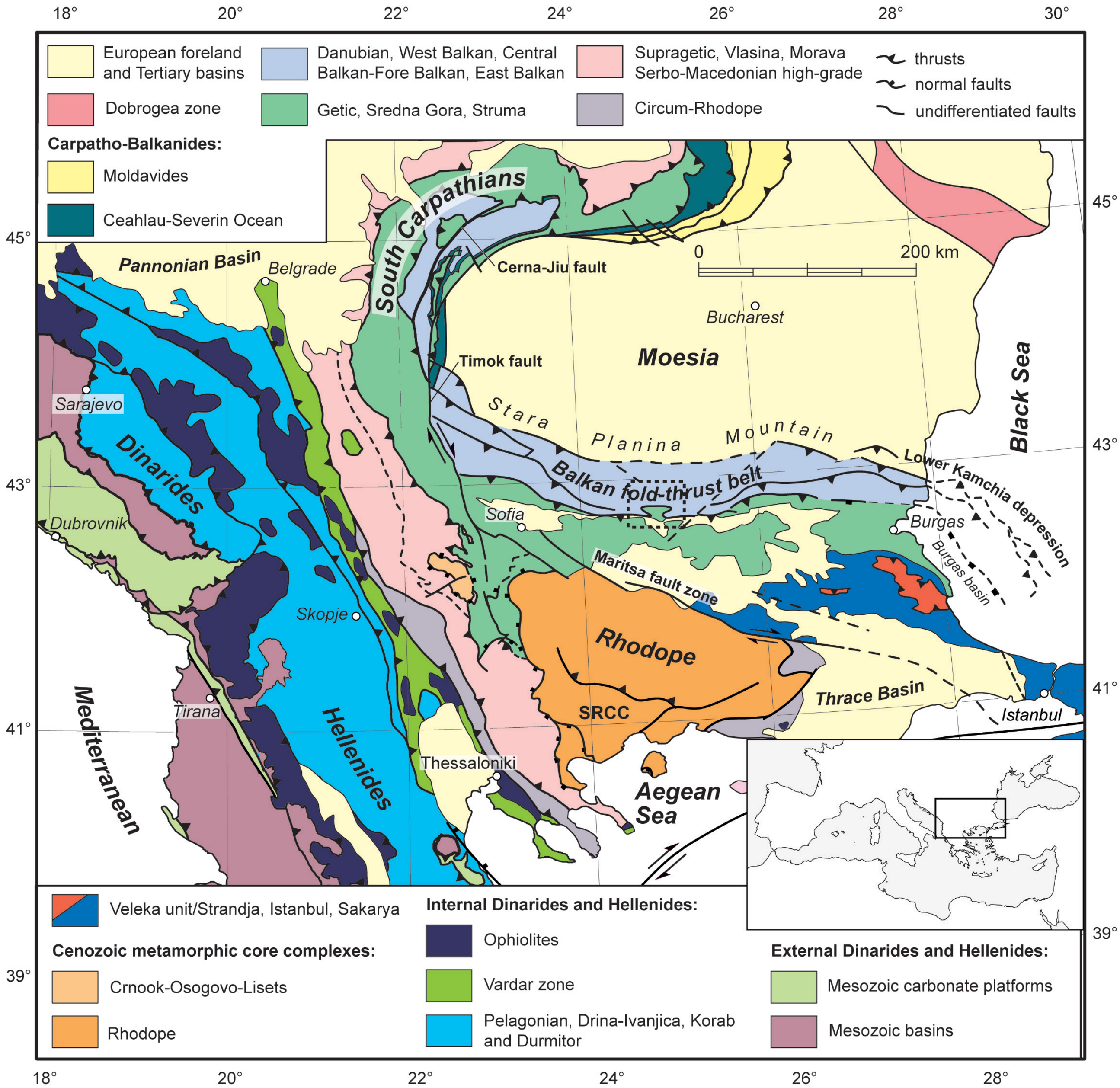

Fig. 1. Tectonic map of the Balkan Peninsula (modified after Schmid et al. 2008; Bernoulli 2001). Box outlines studied area.

thick planar body. Here the foliation planes dip virtually in all directions at mainly shallow angles (20–45°). Hence, the orientation of the generally down-dip lineation is also very variable. These tightly foliated rocks are affected by meso- and micro-scale folds with various morphologies: open to less frequently tight or isoclinal, often chevron-like folds with shallow plunging axes in all directions. No consistent shear sense has been documented within the Ambaritsa metagranites.

The sample for U–Pb LA-ICP-MS dating was taken from the allochthon of the Botev Vrah thrust. 25 spot analyses were made preferentially from the rims, but also from the cores of the zircons. The zircons exhibit well expressed oscillatory zonation typical for growth in igneous conditions of acid to intermediate magmas. Some of the crystals show cores with ages close to that of the rims, suggesting for some magmatic dynamics in the chamber during their formation. The magmatic ages are determined using the eight most concordant analyses and yield an age of 307.8±3.9 Ma (Fig. 3, with weighted average $^{206}Pb/^{238}U$ of 307.8±1.4 Ma). No xenocrystic component has been found.

Localized deformation in the domain occupied by the Ambaritsa metagranites

The Ambaritsa metagranites most probably initially built up a large sheet-like body, later dismembered during the Alpine orogeny. The granite emplacement

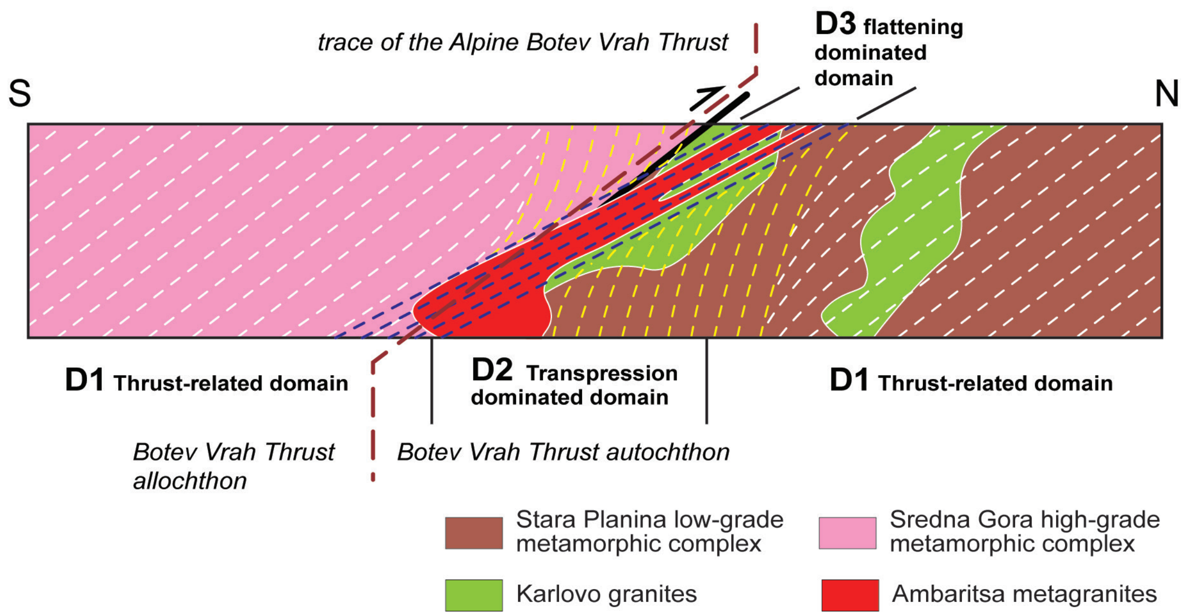

Fig. 2. Scheme for the tectonic evolution of the study area.

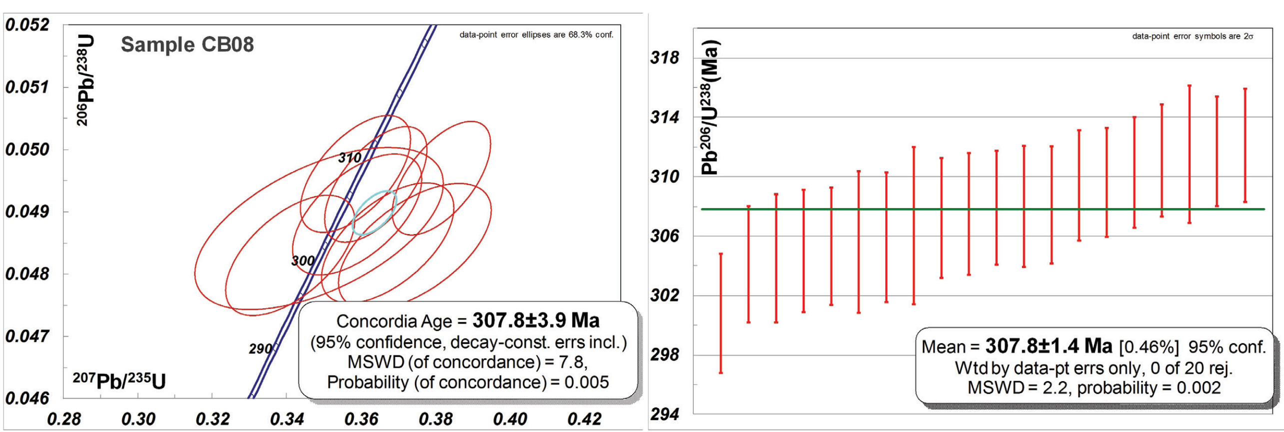

Fig. 3. LA-ICP-MS U–Pb zircon dating of the Ambaritsa metagranites. Concordia diagram (left) and Weighted average $^{206}Pb/^{238}U$ diagram (right).

and deformation postdate an earlier transpressional stage documented in the Karlovo granites and the Stara Planina low-grade metamorphic complex (D2 on Fig. 2) evidenced by a steep foliation and sub-horizontal lineation which were not observed in the Ambaritsa metagranites. Additionally, field data and 3D analysis of the satellite imagery clearly indicate that the steep foliation within their host rocks is rotated to much shallow dips in the vicinities of Ambaritsa granite bodies. The fact that the deformation in the Ambaritsa metagranites took place at a relatively lower temperature (~300–400 °C) than in the host rocks (Karlovo granites and part of Stara Planina low-grade metamorphic complex) suggests that probably at the end of the transpressional phase the rocks from the studied area were exhumed to relatively shallower crustal levels. This lower-temperature overprint is also observed in their immediate host rocks as well as in the enclosed meter to decameter xenoliths.

The deformation of the Ambaritsa metagranites was restricted to a rather narrow zone (up to 400 metres thick) along which they were intruded (D3 on Fig. 2). However, it could not be clearly established what were the relationships between the Ambaritsa intrusion emplacement and the deformation. Though, it could be suggested that both processes were tightly related and probably coeval as the deformation rests confined mainly in the sheet-like Ambaritsa pluton and the later magmatic plutons in the study area are not affected by this specific deformation. Therefore, it could be suggested that the deformation was related to the latest stages of the magmatic activities in a fluid-rich environment.

Generally south plunging lineation observed in the Ambaritsa metagranites and the fact that the foliation is tightly folded suggests that the deformation was probably taken place in a renewed pulse of Variscan compression. The lack of distinct shear sense criteria and rotational features suggests that the deformation was characterised by a significant flattening component in the absence of major displacements.

The differences in the dips and plunges of the foliation and lineation from the Ambaritsa metagranites at the mountain crest and those from the southern slope are probably due to rotations of the former during later Alpine events (e.g. Botev Vrah thrust emplacement). Once restoring the Alpine thrusting along the Botev Vrah thrust it could be assumed that both segments of these metagranites, cropping out now on both sides of the thrust, are parts of the same relatively narrow (not more than 400 m thick) shallow dipping zone of strain localization. Additionally, the fact that later magmatic plutons were not affected by this specific deformation suggests that it has taken place during the latest pulses of the Variscan compression.

Acknowledgements: This study was financed by the Bulgarian National Science Fund Grant (DMU 03/41) and Sofia University Science Fund Grant (180/2009).

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