First thermochronological constraints on the Cenozoic extension along the Balkan Fold-Thrust Belt (Central Stara Planina Mountain) and its relation to the South Balkan geological evolution

Първи термохроноложки данни за Неозойската екстензия в Балканския гънково-навлачен пояс (Централна Стара планина) и връзката ѝ с еволюцията на Южните Балкани

Alexandre Kounov[1], Ianko Gerdjikov[2], Dian Vangelov[2], Eleonora Balkanska[2], Anna Lazarova[3], Stoyan Georgiev[3], Daniel Stockli[4]
Александър Кунов[1], Янко Герджиков[2], Диан Вангелов[2], Елеонора Балканска[2], Анна Лазарова[3], Стоян Георгиев[3], Даниел Щокли[4]

[1] Basel University, Institute of Geology and Paleontology, CH-4056 Basel, Switzerland; E-mail: a.kounov@unibas.ch
[2] Sofia University “St. Kliment Ohridski”, Faculty of Geology and Geography, 1000 Sofia, Bulgaria
[3] Geological Institute, Bulgarian Academy of Science, 1113 Sofia, Bulgaria
[4] The University of Texas at Austin, Department of Geological Sciences, Austin, TX 78712, USA

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Introduction

If the Cenozoic extension in the Aegean region is at present relatively well studied its manifestation north of the Rhodope massif, along the Balkan fold-thrust belt, is still not fully constrained. Being a compressional belt since the Middle Jurassic, during the most of its Alpine evolution, the final exhumation of these rocks during the Cenozoic extension has remained poorly studied.

The Balkan fold-thrust belt, best exposed within the Stara Planina Mountain in Bulgaria and North-East Serbia, along with the Carpathian belt form the north to north-east vergent segment of the divergent Eastern Mediterranean Alpine orogen, whereas the Dinarides and Hellenides represent its south to south-west vergent part. The Balkan fold-thrust belt was formed during two distinct compressional stages, the so-called Early (Middle Jurassic–Early Cretaceous) and Late Alpine (Late Cretaceous–Paleogene) tectonic phases separated by extensional one related to the formation, during the Late Cretaceous, of the Apuseni-Banat-Timok-Sredna Gora magmatic arc and back-arc and/or intra-arc basin. Most of the authors agreed that the Late Alpine compression in the belt had ceased by the Lutetian (47.8–41.2 Ma) based on the presence of compression-related structures sealed by Bartonian sediments (41.2–37.8 Ma; e.g. Bonchev, 1946). In general, the shortening stages as well as the Late Cretaceous extension were linked to the processes accompanying the subduction of the Mesozoic Tethys along the Southern European margin. However, several lines of evidence now suggest that compression continued, at least along some of the segments of the Balkan fold-thrust belt, after Lutetian time. Burchfiel and Nakov (2015) suggested that the compression persisted, at least along the western part of the belt, until the Middle Miocene. They have related this compression to the right-lateral shearing along the western part of the Moesian platform and the formation of Cerna-Jiu and Timok faults during the northward movement of the Carpathians units when invading the so-called Carpathian embayment. Furthermore, Stuart et al. (2011) reported thrust structures in the distal offshore part of the belt (Lower Kamchia depression in Black See Basin), which cut through sediments as young as Oligocene. However, careful inspection of the seismic profiles presented in Stuart et al. (2011) clearly shows that these structures are rather related to gravity-driven tectonics and therefore do not indicate continuation of the compression in the Oligocene. Moreover, during this time the Burgas basin, situated landward the supposed thrust structures, was under extension (Stuart et al., 2011).

South of the Balkan fold-thrust belt, the Cenozoic extension started probably already in the Middle to Late Eocene, or even earlier, and was associated with a development of fault-controlled sedimentary basins,

formation of extensional core complexes and accompanied by mostly calcalkaline to shoshonitic igneous activity. However, the upper crustal extension obviously was contemporaneous with compression at deeper levels. Recent studies have reported compressional ductile shear zones, in the Rhodope, active until 33 Ma (Bosse et al., 2009; Jahn-Awe et al., 2010; Nagel et al., 2011).

The Cenozoic extension in the Balkan fold-thrust belt has been investigated mostly through the Pliocene–Pleistocene evolution of several extensional basins flanking the Stara Planina Mountain to the south, known as the Sub-Balkan graben system (e.g. Tzankov et al., 1996; Vangelov et al., 2010). Middle Eocene to Lower Oligocene sediments at the base of the basin suggested to Tzankov et al. (1996) that the extension and basin formation had begun by this time. The main problem, however, still remains the lack of reliable quantitative age constraints on these processes and on the rates and amount of denudation along the basin shoulders.

Results

Here we present the first geochronological constraints, based on fission-track and [U-Th-(Sm)]/He analysis, showing that along the central part of the Balkan fold-thrust belt the extension has started already in the Middle Eocene. Low-temperature thermochronological analysis of samples collected from 3 areas in the central part of the Balkan fold-thrust belt revealed at least two phases of increased cooling and exhumation. The first stage took place between ~44 and 30 Ma and was coeval with the earliest Cenozoic extensional stage observed along the Southern Balkan Peninsula. After a period of relative quiescence the next cooling stage, between 25 and 20 Ma, was related to the Late Oligocene–Early Miocene crustal extension along the Balkans. The third, latest Miocene–Quaternary extensional stage in the Balkan fold-thrust belt, related to formation of the Sub-Balkan graben system obviously did not produce exhumation of rocks from 2 to 4 km depth during this period, as it was not detected by the low-temperature thermochronological methods.

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