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## *Problemata et disputationes*

# Comment on: "Shanov, S., Sans de Galdeano C., Galindo-Zaldivar J., Radulov, A., Nikolov G., Azacon, J. M., Yaneva, M. 2007. Late Alpine deformations, Neotectonic evolution and Active tectonics of the southern border of Central Balkan Mountain: a new contribution. – *Geologica Balc.,* 36, 3–4, 41–50"

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The topographic relief of Central Stara Planina Mountain and the deeply incised valleys provide a particularly appropriate field area to study the complex overprinting between several phases of Alpine compression and extension. After a quarter of century break in structural studies (the work of Bakirov et al., 1984), Shanov et al. (2007) provided the latest update to our knowledge of tectonic evolution of this key area. We have been working in the same area for a number of years. We are concerned about several points presented and discussed by Shanov et al. (2007). Our comments are regarding not only the discussion and the statements, but are mainly devoted to the applied methodology.

The paper of Shanov et al. (2007) is contributing new geological data in two fields: data about the "petrographical characteristics" of the tectonites of Botev Vrach thrust (or Stara Planina thrust) and also about the attempts to calculate paleostress regimes. We are about to comment on these two approaches, but first there is a need to mention the total lack of precise geographical data for the position of the studied locations. This fact is inescapable obstacle to have reproducibility of the primary scientific data.

It is fairly obvious that the studied area is displaying heterogeneous fault populations which originate from polyphase deformation. In such complicated cases there are two possible approaches: the first one is to reconstruct local chronologies on the basis of meso-scale observations (cross-cutting relations, faulting style, associated with faults new crystallization), and the second one is to use various methods to process and refine field data (e.g. PBT-method – Sperner et al., 1993; multiple inverse method – Yamaji, 2000; the data processing method of Zelinger et al., 2000). None of these methods has been applied by Shanov et al. (2007). It is difficult for the reader to understand on what base the subdivision of the reconstructed tectonic stress fields shown in Table 1 has been made. Time constraints are very poor or completely lacking. For example, to motivate the existence of Early Cimmerian paleo-tectonic stress field is said that the data come from the rocks no older than Triassic (p. 47)! The question with the "Atian phase" is even more acute — there is no line in the paper that is devoted to the affected rocks, their age, geographical position, style of deformation, etc.

There is also a serious concern about the lack of data describing the quality of shear-sense determination and on the quality of paleostress tensors. In most of the papers dealing with fault-slip analyses at least a single quality criterion is provided – misfit angle (average slip deviation). There are even attempts to quantify the quality of the calculated stress tensors (e.g. Champagnac et al., 2006). Such information is not available in the work of Shanov et al. (2007).

Our last comments on the proposed reconstruction of the paleotectonic stress fields are concerning the very basics of the methodology of fault-slip analysis. As far as the detail of the Fig. 1 of Shanov et al. allows, it seems that most of the data come from the areas situated within the major fault zones. And something more – our data from the same area indicate that most of the involved in the Late Alpine tectonics rocks possess strong anisotropy – for example foliated Variscan granitoids (north of Karlovo and villages of Vasil Levski and Tazha). In such case it is obvious that the assumption of stress homogeneity and low finite strain (coaxial) are not met (e.g. Twiss and Unruh, 1998).

The petrographical characteristic of the Late Alpine thrust zone (Central Balkan thrust; Botev Vrach thrust – Cheshitev, 1958; Stara Planina granite thrust – Bonchev, Karagjuleva, 1961) is incomplete (6 sentences long!) and does not provide decisive arguments for the proposed interpretations. It is striking that there is no description of the architecture of the thrust zone. From the brief description on page 45 it is obvious that for the authors this fault zone is represented by a single thrust surface! Instead, our data from the same area (north of Karlovo, village of Vasil Levski) point to the existence of complex imbricate structure with commonly up to several meters thick fault zone. It is well known that the footwall of the thrust consists of various rocks – granitoids, Cretaceous and Paleogene sediments (Cheshitev, 1958; Bakirov et al., 1984). The presence of incompetent lithologies as Cretaceous limestones in immediate footwall is leading to pronounced strain partitioning. We are about to publish more detailed description of this contact zone (Balkanska and Gerdjikov, in preparation), but for the purposes of this short communication it is important to note that in numerous cases the Cretaceous limestones from the footwall form 2–20 m thick tectonic zone with thrust-related tectonite fabric. There are no data on the existence of imbricate structures, as well as data on this specific deformation of the limestones in the paper of Shanov et al. (2007).

The description of Shanov et al. (2007) is so incomplete that there is no information on the position of the studied samples – whether they are from the footwall or from the hanging wall. Just preliminary knowledge of the local geology can help to resolve this problem: most probably samples are from the hanging wall of the thrust. We have three questions concerning the petrographical descriptions: (1) Why there is no comparision between the fabric of the studied rocks within and outside the thrust zone? (2) Is the commented mylonitization related to the thrust emplacement? To answer the second question there is a need to know the fabric of the allochthonous granitoids, e.g. to know well the fabric of the protoliths of the rocks involved in the fault zone. In most of the places along the studied thrust zone the Variscan granitoids from the hanging wall, as well as from the footwall, are intensively foliated (e.g. Gerdjikov et al., 2008). (3) We are expressing reservations about the possibility to distinguish compressional from extensional stages of regional tectonic evolution on the basis of thin-section examination. According to Shanov et al. "A network of cracks filled in by late quartz and crossing the mylonite foliation represents the extensional stage, following the compression." First, it is not at all clear whether the mylonitic foliation is related to the nappe emplacement. Our data are more consistent to interpret this fabric as a result of Variscan tectonics. Second, there is no need to invoke second deformation event to produce orthogonal to the foliation cracks. Such cracks can well be formed at a high angle to the extensional direction during progressive deformation or can be a result of high fluid pressure.

Finally, we have some more questions about the presented results and interpretations:(1) What are the reasons to revive the idea about the gravitational origin of the Stara Planina granite thrust sheet? We are confused by this interpretation even more, because Shanov et al. (2007) do not comment on the data presented by Bakirov et al. (1984), although the latter presented comprehensive structural investigations for some of the areas studied in the paper of Shanov et al. (2007) as well.

(2) The reconstructed Pliocene-Quaternary paleotectonic stress field is characterized by shallowly dipping $y_1$ axis. How this orientation is explained in the context of the current geodynamics?

(3) On page 48 there are claims that "old thrust surfaces" were "later folded during Atian phase...". First, due to the lack of description it is not clear how this folding event was established; and second, if the Late Alpine thrusts are folded, has this folding/rotation been taken into account especially in regard to presentation and interpretation of paleostress data?

(4) It is well known that the most important unconformity in the Central Balkan area is at the base of Upper Cretaceous rocks (e.g. Cheshitev, 1958) and this marks pronounced stage in evolution of the Alpine chain – Early Alpine orogeny ($J_3$–$K_1$, e.g. Dabovski et al., 2002). According to Shanov et al., the first Alpine event is with Upper Jurassic age (see their table 1). This assumption is rather unlikely, especially in regard to well-known uninterrupted sedimentation in the interval Hetangian-Berriasian in the area of Central Balkan (e.g. Cheshitev et al., 1994).


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## REFERENCES


Bakirov, A. B., Bac-Moszaswili, M., Brezsnyansky, K., Georgiev, E. A., Pironkov, P. S., Slavkovski, I., Stoajanov, S. S., Tzankov, Tz., Jaroszewsky, V. 1984. Structural Features of the Band of Stara Planina Granite Nappe between Sopot and Tazha (Central Balkanides). *Geotectonics, Tectonophysics and Geodynamics,* 17, 3–34.

Bonchev, E., Karagjuleva, I. 1961. Das Srednogorije antiklinorium und die Staraplanina-granituberschiebungsde-

cke. *Travaux sur la geologie de Bulgarie* 2, 31–42 (in Bulgarian).
Champagnac, J. D., Sue, C., Delacou, B., Tricart, P., Allanic, C., Burkhard, M. 2006. Miocene orogen-parallel extension in the inner Western Alps revealed by dynamical fault analyses. *Tectonics* 25, TC 3014, DOI: 10.1029/2004TC001779.
Cheshitev, G. 1958. Geologie du naut Balkan entre les cols de Troian et de Chipka. *Annales Direction Generale Recherches Geologiques* 9, 1–27 (in Bulgarian).
Cheshitev, G., Nikolov, T., Milanova, V., Chontova, Tz. 1994. *Explanatory note to the geological map of Bulgaria on scale 1:100 000, Trojan map sheet*. Sofia, 105 pp. (in Bulgarian).
Dabovski, Ch., Boyanov, I., Khrischev, K., Nikolov, T., Sapounov, I., Yanev Y., Zagorchev, I. 2002. Structure and Alpine evolution of Bulgaria. *Geologica Balcanica* 32(2–4), 9–15.
Gerdjikov, I., Lazarova, A., Balkanska, E., Dimov, D. 2008. Massive granitoid magmatism along a major Variscan tectonic zone in Central Balkanides. *Proceedings National Conference Geosciences 2008, Sofia,* 93–94.
Shanov, S., Sans de Galdeano C., Galindo-Zaldivar J., Radulov, A., Nikolov G., Azacon, J. M., Yaneva, M. 2007. Late Alpine deformations, Neotectonic evolution and Active tectonics of the southern border of Central Balkan Mountain: a new contribution. *Geologica Balcanica* 36(3–4), 41–50.
Sperner, B., Ratschbacher, L., Ott, R. 1993. Fault-striae analysis: a Turbo Pascal program package for graphical presentation and reduced stress tensor calculation. *Computers and Geosciences* 19, 1361–1388.
Twiss, R. J., Unruh, J. R. 1998. Analysis of fault slip inversions: do they constrain stress or strain rate? *Journal of Geophysical Research* 103, 12205–12222.
Yamaji, A. 2000. The multiple inverse method: a new technique to separate stresses from heterogeneous fault-slip data. *Journal of Structural geology* 22(4), 441–452.
Zeilinger, G., Burg, J-P., Chaudhry, N., Dawood, H., Hussain, S. 2000. Fault systems and Paleo-stress tensors in the Indus Suture Zone (NW Pakistan). *Journal Asian Earth Sciences* 18, 547–559.