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Comments on the feasibility of the syn-metamorphic nappe complex in Rhodope massif

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The hypothesis about the existence of a syn-metamorphic nappe complex in the Rhodope massif (Burg et al.q 1996) has been repeatedly published during the last years. It is widely known that thrusts planes do exist in Rhodope massif. Most of the well documented thrusts represent low-temperature, high strain-rate discontinuities (Zagorchev et al., 2000). In this light, the current publication is not intended to challenge the evidences for thrusting at all. Its goal is to inspire discussion about the mechanical basis of large-scale trusting coeval to the high-grade metamorphism of the Rhodope massif. The authors of the hypothesis implicitly stated that: 1.The massif is a pile of syn-metamorphic thrusts and nappes. 2.The thrusting was contemporaneous with metamorphic culmination that produced biotite, garnet, staurolite and kyanite in muscovite-bearing metapelites. 3.The pile is 18-20 km thick. 4.During the thrusting and nappe gliding lateral movements of "tens to hundreds of kilometers" have been accomplished. 5.Detachment planes between the lower (gneissic) and upper (amphibolitic) terranes have been distinguished throughout the massif. 6.The movement direction and amplitude have been inferred only on the ground of kinematic analysis data as micro- and meso-scale shear-sense indicators formed in plastic, high-temperature environment. 7. No rapid change of the metamorphic grade across the thrust surfaces has been recorded: "Both thrust units have suffered medium pressure metamorphism during the main phase deformation and they do not display any break in metamorphic grade across the mylonitic contact". 8. The sense of movement has been determined as south to north in 1988, and later on (in 1990, 1996) as north to south. 9. There are not detailed maps and seismic profiles in support of the hypothesis. Taking into account the thickness of the rock sequence reworked in amphibolite facies conditions, and the PT field of the metamorphism itself, it could be inferred that the proposed depth of detachment goes as deep as 30-45 km at the time of its formation. As it is known from the classic (and may be already old) literature, there are some mechanical problems associated to nappe gliding at such big depth, as follows: 1. The classic Andersonian theory states that during thrusting the minimal stress is vertical, and generally, thrusting is examined as possible at shallow depths so that compatibility problems caused by the weight of the thrusted mass could be overcome. 2. It is not clear how, in state of bulk plasticity, big differential stress (σ^1-σ^3) can be supported enough to afford upward movement or lateral gliding. 3. The "mechanical paradox" of the large over-thrusts require anomalous high fluid pressure to be involved at the basement of the thrust in order to diminish the frictional resistance of the moving plates. It is not very clear whether anomalous fluid pressure can be concentrated at high temperature conditions and in such wide flow zones, where the fluid energy is dissipated because of the lack of mineral skeleton able to channel it. At least, field evidences for concentration of such pressure are lacking compared with the distinct hydraulic fracturing at shallow depths (Cosgrove, 1992). The recent advancements in rock mechanics (Ranalli, Yin, 1992) indicate that the critical stress difference required to initiate

thrusting at such big depth surpasses the strength of the rock, so the shear cannot be concentrated on a distinct plane. 4. In high pressure and temperature environment shear sense indicators may form by a very small perturbation of the energy. It is not necessary to invoke thrust planes or detachment surfaces in order to explain them. The adequacy of the shear-sense indicators to predict successfully the sense of movement, without independent confirmation of the results, has been seriously challenged in some recent works (Jiang, Williams, 1999). 5. In the deep levels of the crust thrusting should be accomplished by crystal-plastic-deformation and it is widely known that it is a slow deformation mechanism, so unrealistic time span is necessary to build the mentioned pile. In addition, we should keep in mind that: 1. The metamorphism of the Rhodope massif is not related to narrow shear zones but it is large-scale, regional metamorphism, accompanied by intensive migmatization. 2. According to the personal observations of the author and other researchers (E. Kozhoukharova, I. Zagorchev, personal communications), shear-sense indicators are found at all levels and frequently show contradictory sense of movement in all scales, so it would be extremely difficult to deduce consistent sense of shear on the scale of the entire massif as the authors do. 3. The proposed detachment surfaces do not expose sharp deformation gradients, and generally, they are not well defined. The authors stated that "Reduction in grain size, as well as porphyroclast content, are diagnostic for strain gradients from protomylonites to ultramylonites", however, it is generally assumed that grain-size reduction is not a dominant deformation mechanism at high-temperature conditions (Bell, Johnson, 1989), and "the work hardening aspects of the failure are generally suppressed at high-temperature conditions" (Knipe, 1989). Thus, high-temperature grain-size reduction seems unrealistic. In the discussed publication is stated "that deformation took place close to plane strain, that the strain intensity is reasonably homogeneous on a regional scale (but with marked changes in shear strain), and that little volume variations were involved". From the above citation follows that variations of the shear strain were the major criteria used for distinguishing the deformation gradients. These remarks, together with the overall PT conditions of the metamorphism, and the observations of the previous researchers imply that, at least, some of the shear planes encountered by the authors of the discussed work are low-temperature, brittle-ductile or brittle deformation zones which can not be examined as coeval to the high-grade metamorphism.

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