Is the Lower tectonic unit (Lower terrain) in the Rhodope a monolithic tectonic unit

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The geological correlation of high grade metamorphic rocks across the Rhodope massif in Southern Bulgaria and Northern Greece has been controversial for decades. Two different models with contrasting approaches to correlation are employed today. According to the first model, the Rhodope massif is viewed as a stable crustal fragment of Precambrian age. Proponents of that model use a litostratigraphic approach to sub-divide and correlate metamorphic rocks across the massif. The second model considers the Rhodope massif a stack of tectonic plates that consists of two major tectonic units (a.k.a. the Upper and Lower terrains) separated by several mylonitic zones and "intermediate" tectonic units. Supporters of the latter model employ lithotectonic principles to subdivide and correlate metamorphic rocks across the massif.

Both models, however, correlate massive marbles that crops out near the villages of Trigrad and Yagodina, i.e., in the southern section of the massif to marbles cropping out to the north near the town of Assenovgrad. According to the different classification schemes applied by the two models, marbles are either a part of the Dobrostan Formation (model 1) or the Asenitza lithotectonic unit (model 2).

We use stable isotopic determinations and microscopically characteristic of marbles from three different localities to examine the application of this investigation for tectonic correlations.

Locality 1 (L1) - Aseinitza lithotectonic unit. The investigated marbles are massive, poor calcite with a medium grained equigranular texture. Rare xenoblastic quartz and white mica (colorless phlogopite ?) grains are observed, too. The calcite grains contain numerous lamellar or intersecting deformation type III twins. Calcite MgO contents vary in a narrow range (0.68-0.81%), hence, the minerals can be classified as low-Mg calcites. Samples from this location have nearly identical $\delta^{13}C$ compositions, i.e., from +0.14 to +1.57 %o (average +0.66, n=4). The $\delta^{18}O_{marble}$ values range from -5.50 to -6.40 ‰ (average -5.88, n=4), respectively.

Locality 2 (L2) - Lower terrain. The samples comprise massive, poor calcite marbles. In contrast to the samples from L1, L2 samples have unequigranular texture. Relatively big calcite grains "float" in fine-grained recrystallized matrix. The large crystals have lobate outlines and core-mantle texture is a specific feature of these rocks. Wide lamellar and intersecting deformation twins are characteristic features of the big calcite grains. The MgO content of matrix calcite is 0.75-0.86%. L2 samples exhibit significant isotope variability with two samples having higher ^{13}C and lower ^{18}O compositions, respectively. As a result, the $\delta^{13}C$ values of the samples vary from +2.16 to +4.21%o (average +3.18, n=4), while their $\delta^{18}O$ vary from -2.40 to -10.60 (average -6.61, n=4), respectively. If previous data are considered, average $\delta^{13}C$ and $\delta^{18}O$ values are +1.96‰ and -1.98‰, respectively. The cause of the significantly different isotope values of the two L2 samples is likely related to localized water-rock interaction.

Locality 3 (L3) - Asenitza lithotectonic unit. The samples were collected along the road to the Yagodina cave. These have massive structure and, in contrast to the L1 and L2 samples, contain dolomite. Texturally L3 samples are similar to L2, however, matrix calcite in L3 samples is slightly coarser. The large clasts in the L3 samples contain up to 3.30 % MgO, while matrix calcite MgO contents vary 0.77-1.67 % and are, thus, comparable to these of L1 and L2 calcites. The $\delta^{13}C$ values range from +1.03 to 2.07%o (average +1.67, n=5) and the $\delta^{18}O$ from -2.00 ‰ to -4.30‰ (average -3.65‰, n=5). The $\delta^{13}C$ and $\delta^{18}O$ values of these samples do not vary significantly.

Metamorphic P-T conditions in the marbles and the enclosing lithologies are estimated using calcite-dolomite solvus thermometry and other conventional thermometers. For chloritoid-bearing metapelites from the area of the village of Byala Cherkva (Asenitza unit) the results are: 330-360 ^{o}C at 5 kbar (Bt-Ms thermometer) and 350-370 ^{o}C at 5 kbar (Grt-Bt thermometer). The calcite-dolomite solvus thermometry of dolomite-bearing marbles from L3 yields 360-470^{o}C at 5 kbar for the matrix calcite and 560-610 ^{o}C at 5 kbar for the large calcite clasts. Those PT conditions are comparable to values determined from metapelites from the Lower terrain in northern Greece.

Marble samples from the three different locations in the Rhodope massif exhibit significant mineralogical, textural and stable isotope differences. While L2 and L3 samples have similar textural characteristics and stable isotope compositions, these differ from the Asenitza unit (L1) samples. That indicates that marbles from the southern part of the Rhodope massif (i.e., the Yagodina and Trigrad area) are part from the Lower terrain (Lower tectonic unit) or Pangeon unit i.e. they present a tectonic window.

Recent tectonic activity of the Polish Western Outer Carpathians: Geomorphic and gravimetric constraints

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Two geodynamic test transects across the Polish segment of the Western Carpathians, crossing the Orava Basin in the west (KO) and the Pieniny Klippen Belt and Magura Nappe along the Dunajec River valley in the east (DD) have recently been analysed. Multidisciplinary studies conducted along these transects included gravimetric, geodetic, geologic and morphostructural investigations. Gravimetric and geodetic results appear to suggest recent subsidence of the Orava Basin, particularly intensive in the Wróblówka Graben, confirming conclusions derived from geomorphic analyses. Data obtained for the Dunajec River transect do not show any particular differentiation among individual benchmarks, what can point to either minor uplift of the entire area (already suggested by the results of geomorphic and morphotectonic studies), minimal differences between successive slices of the Magura Nappe and the Pieniny Klippen Belt, or both. Horizontal displacements of benchmarks, different for the KO and DD transects, towards the west and SW as well east and SE, respectively, can result from general uplift of the area comprised between these transects, i.e. the Gorce Mts. A new geodynamic transect DS, running along the Soła River valley cuts several units of the Outer Western Carpathians of Poland. These are, from the south, the Magura Nappe, Fore-Magura group of nappes, as well as the Godula and Cieszyn units of the Silesian Nappe, sub-Silesian Nappe, Skole Nappe, and the Carpathian Foredeep. Within the Magura Nappe, thrust faults of subordinate units (slices) are of the order of a few kilometres, and individual slices are composed of strongly imbricated anticlines and synclines striking SW-NE. The Fore-Magura group of nappes is composed of thrust sheets including both Magura- and Silesian-type lithostratigraphic members that build strongly imbricated folds of northern vergence. The Silesian Nappe is subdivided in this portion of the Western Carpathians into the Cieszyn (northern part) and Godula (southern part) units. In a tectonic window close to Żywiec, the Godula unit is underlain by the Cieszyn unit which overlies the sub-Silesian Nappe. Strata belonging to the latter nappe are exposed farther north in a number of small-scale outliers in front of the Silesian Nappe, north of Bielsko-Biała and close to Kęty-Wadowice. The nappe is composed of several north-verging imbricated folds, thrust one over another. All these units are cut by strike-slip and oblique-slip faults oriented roughly N-S. One of the most prominent fault zones accompanies the Soła River valley, dextrally offsetting the Carpathian frontal thrust. These faults were mainly formed during final stages of thrusting of the flysch nappes, postdating Burdigalian time. The discussed western portion of the Outer Carpathians is traversed by several sets of regional and local photolineaments, coinciding to a large extent with the Soła River fault and associated subordinate faults. In the