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Abstracts

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The first estimation of volumes of eroded rocks of the folded Alpine sedimentary cover of Greater Caucasus for three geodynamic models having different shortening of space

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Use of calculation of erosion volumes for a upper part of folded complexes can be one of ways of checks of structural and geodynamic models. These theoretically predicted volumes can be compared to volumes of deposits of molasse in foreland basins, which were accumulated when the forming of a folding and of an uplift of a mountain building took place. Such comparison allows to make conclusions about realness of geodynamic models, which are checking [Yakovlev, Sorokin, 2016].

Three essentially different types of geodynamic models were put forward for the structure of Alpine Greater Caucasus. The differences in values of shortening of sedimentary cover and in styles of behavior of the Hercynian metamorphic basement are discerning these models from each other. The first developed model [Milanovsky, 1968] was related to the fixism conception; a shortening of a sedimentary cover and of blocks of the basement was absent in this model. The second type of models exists in a large number of versions, for example, [Dotduyev, 1987]; the principles of plate tectonics were used as their theoretic base. In these models, the considerable shortening of structures of a sedimentary cover (at least 80%) is supposed. An accretionary prism above the rigid and not deformed basement, which was subducted under the Caucasus, was most typical feature of the structure. The third developed model is the balanced structure of a sedimentary cover; it was created as a result of direct measurement of fold related shortening by methods of structural geology [Yakovlev, 2009; 2012; 2015]. Shortening in this model for relatively small blocks was found as about 50%, such deformations embraces both the sedimentary cover, and the basement beneath.

The method of measurement of value of shortening on the first step and of a restoration of structures of the cover on the second one bases on notions of tectonophysics [Yakovlev, 2009]. Structures of a sedimentary cover and larger structures are considered as set of objects of seven hierarchical levels, from intra-layer objects (deformed grains) and usual small folds to entire mobile belt. According to this hierarchic system, usual folds (the 2nd level, the width is 0.05 – 0.2 km) unite as "folded domains" (the 3d level, from 0.5 to 1.5 km), these domains unite as "structural cells" (the 4th level, from 5 to 10 km). Deformations of folded domains are described by an ellipsoid of deformations, which is connected with its geometrical parameters (inclination of fold axial plane, interlimb angle et cetera). Materials of 24 detailed structural profiles with a total length about 500 km were divided into 505 domains and its parameters were measured. Each domain was restored to its pre-folded situation by the sequence of kinematic operations such as: 1) rotation, 2) horizontal simple shearing and 3) stretching or pure shearing [Yakovlev, 2009; 2012]. At the same time, the ellipse of deformations became a circle, and the modern segment of the cross-section line in the domain got other length and an inclination, forming the pre-folded structure. Combination of such 3-10 domains in each of “structural cells” allowed ascertaining the modern width and the pre-folded width of structures. Thereby the value of shortening for such cells were easily calculated. The known position of domains in an entire stratigraphic column of the cover, based on age of rocks and on the depth, and also the value of shortening and altitude of section line on the ground in a cell, allowed to restore the modern depth of a sole of a folded sedimentary cover (i.e. of a top of basement) and volume of eroded rocks [Yakovlev, 2009; 2015]. For the Greater Caucasus, the dataset of 78 such structural cells was saved up that allowed to make reliable structural generalization for the western and eastern parts of this folded system.

Volumes of eroded rocks as a difference between the volume of neotectonic uplift of Greater Caucasus [Milanovsky, 1968] and the volume of the mountain topography were counted for model of the first type. Polygons of the map of size of 20x30 minutes of coordinate grid were used for calculations, and average sizes of neotectonic raisings during 15 m. y. in these polygons were estimated ([Grachev, 1997] after [Milanovsky, 1968]). Of course, volumes of uplift of all polygons were summed up finally. Average height of a neotectonic uplift was estimated at 3-5 km in neotectonic map, the volume of a raising totally was calculated as 279 thousand km^3. The volume of a modern mountain building was counted according to the digital map of a topography of Greater Caucasus, it was 119 thou. km^3. Thus, the volume of erosion for entire Greater Caucasus was counted as 160 thou. km^3, and for those part of building, which is source of sediments for the Black Sea basin - 87 thou. km^3. Calculations for the basin of the Black Sea separately were important because only Greater Caucasus delivered material in these forelands and sea basins. In the third model, which has the balanced structure, the “virtual” or theoretical position of top of sedimentary cover after upraising with the parallel erosion was estimated as 10-15 km in average for 78 "structural cells".

Volumes of an uplift and erosion for the third model [Yakovlev, 2015] were counted also on the same polygons with some interpolations and extrapolations. The volume of erosion was estimated as 826 thou. km^3 for entire Greater Caucasus and 448 thou. km^3 for the part, which related to sedimentary basins of the Black Sea. Authors themselves did not evaluate eroded rocks volume for the second model with very large shortening [Dotduyev, 1987], but they do not object to traditional estimates of an uplift in 3-5 km (after [Milanovsky, 1968]). In the absence of their data, we estimated possible erosion using the idea of preservation of volumes of rocks at all processes. The announced in the model a minimal shortening of 200 km for the structure of 50-60 km modern width gives shortening of 80% (the relation 250 / 50 km). Taking into account the average initial thickness of a sedimentary cover of Greater Caucasus in 13 km and the modern depth of the basement about 10 km, declared in the model, an erosion during of uprising in accretionary prism was evaluated as 55 km. Proportional increase in volume of erosion in comparison with the balanced model in this case (55 km against 15 km) gives for the second model (accretionary prism) the volume of 2950 thou. km^3 as minimum for entire Greater Caucasus and 1601 thou. km^3 for basins of the Black Sea part.

Collecting of materials on thicknesses of complexes of the molasse represented a difficult task. For this purpose, several maps and some materials of geophysical profiles were used. Calculations of volumes were made also on polygons of coordinate grid. The volume of Cainozoic deposits in all basins surrounding Greater Caucasus was evaluated as 2609 thou. km^3, including very big thickness (10-15 km) in the basin of the Southern Caspian Sea. The volume of sediments for the part of the basin of the Black Sea was 592 thou. km^3. Comparison of volumes of erosion for three models with the counted volume of sediments, which exists in nature, was made. Erosion volume for the first model (fixism) was 15% of the actual volume of sediments in Black sea basins (87/592), on the balanced model – 76% (448/592), the model of an accretionary prism gave 270% (1601/592). Thereby comparison to three geodynamic models shows the realness only of the model of the balanced structure [Yakovlev, 2015] in which a joint shortening of structures both sedimentary cover and the basement has moderate estimates – about 50%.

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