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About the Combination of Two Mechanisms of Mountain Building (the Shortening and the Underplating) in the Forming Processes of the Tien Shan, the Pamir, and the Afgan-Tadjik Basin

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The mountain building is closely connected with the increasing of the thickness of the continental crust, and with the isostasy phenomenon. In one's turn the increasing of the crust thickness is associated usually either with the shortening of the crust (as example, [Avouac et al, 1998] or with the process of the underplating (as example, [Grachev, 1999]). The Moho boundary in such models is considered as marker level (the first case) or may to move along the column of lithosphere rocks (the second case). We study the ratio of these processes on the three regions example [Grachev (ed.), 2000].

The Tien Shan was choiced as basic region for this work. The two methods to obtain the values of shortening were used and the results were compared [Yakovlev, Yunga, 2001]. There were "geological" and "crust thickness increasing" methods. The first method was based on facts of geological history of region. All three regions have had platform stage before Oligocene and considerable areas of peneplains were produced. These surfaces have been deformed by buckling and thrusts during the subsequent mountain building processes. The shallow-water limestones are well dated and well marked these surfaces [Burtman, 2000]. Some geologic and geomorphologic cross-sections (more than 10 large, [Chediya, 1986]) were good drown, and all bends and fault displacements of marked surfaces were good outlined. The shortening values were calculated as ratio between recent length of surface line and length of its horizontal projection. The shortening values both for total sections and for short portion of sections were calculated by the first method. The second method was based on map of magnitude of neotectonic elevations as well as the map of Moho boundary depth.

The modification of method was that the shortening value and the direction of maximal shortening were determined for the geographic net cells 20’x30’. The maps of normalized values of shortening were constructed for the results of both methods.

The comparison of two maps has shown that at least two coincidences exists. The places of local maximum were the same for two maps. The shortening values have increased from east and west margins of the Tien Shan to the center of the range. It means that both methods have produces the same results in the quality level. The quantity properties of results were study also. The total shortening of 8 common meridional sections for results of each methods were obtained. The right correlation value for two rows of estimates was 0,87. But the estimate of zero shortening for the first method (“geological”) has corresponds rather well with 12% of shortening for the second method (“increasing of the thickness of the crust”). If the “geological” measurements are right and true, we may think that the second method gives too high estimates. These facts (the right correlation and the raising too high of the second methods estimates) may be explained by hypothesis that two kind of processes take place in the Tien Shan. There are 1) increasing of the crust thickness due to real shortening, and 2) underplating due to the displacement of the Moho boundary down along the lithosphere rock column. The average increasing of crust thickness ($\sim$ 15 km) in Tien Shan may be explained by the equal roles (by about 5 – 7 km) of each processes. The nature of such convergence may be the matter for the discussion. There is additional model for the explanation of the mountain building of the Tien Shan by pressure from the Pamir and the Tarim blocks. The theoretical evaluations of the width of the zone of impact from an actively moving continental plate on its neighboring less rigid lithospheric regions were made [Bobrov and Trubitsyn, 2000]. The width of such a zone coincides roughly with the lithospheric thickness (300 km), which, to a first approximation, corresponds to the entire width of Tien Shan (300–450 km).

Trifonov V.G. [Trifonov et al., 2006; and oral report also] has used the idea of two mechanisms existence and our data of shortening value for the correlation of these processes during the mountain building in Tien Shan. Trifonov has found based on data of the sedimentation and of the deformations of sediments that velocities of shortening are increasing during this period. The calculated uprising of peneplains due to appropriate increasing of the crust thickness is comparatively slow. The other part of uprising (due to swelling of matter of mantle and crust) has much more acceleration at the same period. It means that the second mechanism (“underplating”) had more and more dominant role during the mountain building in Tian Shan.

Measurements of the shortening value for the earth’s crust by the first method were also made at Pamir (2 profiles, [Chediya and Trofimov, 1962]) and within the Afghan-Tadjik depression (5 profiles, [Bekker 1996]). According to structural data, shortening values within the Afghan-Tadjik depression and at Pamir were about 35-60% and less than 1%, respectively. The thickness of the crust in these areas is about 35-45 km and 60-65 km, respectively. If taking into account deformations within the two regions, the initial Moho boundary (where Moho serves as a marker) should be moved down from 40 km to 60-80 km in the first case, and should remain at $\sim$40 km in the second case. Thus, the Moho boundary really moved up (the Afghan-Tadjik depression) and down (Pamir) along the lithosphere column by at least 20 km. Theoretically, there exists an explanation of changes in geophysical properties "crust-mantle" by phase transitions "gabbro-eclogite" purely, which can also explain the displacement (the current position) of the Moho boundary in Tien-Shan. However, such iso-chemical model is hardly probable acceptable for the Afghan-Tadjik depression and for the Pamir. From our point of view, to ensure changes in the rock properties from the "crust" to the "mantle" and vice versa, introduction and exportation of the Ka-Na and Fe-Mg materials is necessary.

Conclusions: The model is found for Tien-Shan, which combines two mechanisms of the mountain building (such as, shortening and underplating) and satisfactorily describes quantitatively deformations of the region. Comparing the deformation values and the locations of the Moho boundary in the three considered regions has shown that using the Moho boundary as the deformation marker without additional independent estimation of the crust shortening may lead to substantial errors.

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