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Large stresses in the lithosphere in regions of strong Neotectonic uplift

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Several mechanisms have been proposed to explain the drift of lithospheric plates: subduction pull, basal drag, ridge push and some other ones. Among them only ridge push can be quantified reliably enough as (1.5-2)$\times 10^{12}$ Nm (Artyushkov, JGR, 1973, 78, 7675-7708; Geodynamics, Elsevier, 1983, 312 p.). Due to uncertainty of another mechanisms, estimates of the forces acting along the lithospheric layer still differ by one order of magnitude. Ridge push is only a special case of the forces produced in the gravity field by density heterogeneities in the crust and subcrustal lithosphere. These forces generally increase with the potential energy stored in the relief. This allows us to estimate what force is necessary to shorten the crust with its surface reaching a certain altitude. As follows from a large volume of data, strong shortening of the crust in folds belts usually produced a ragged topography. However, after its erosion in a few million years the crustal surface remained near to sea level and mountain building occurred after the termination of crustal shortening. Thus the present Alps were formed during the past 5 Ma after 99% of shortening in them were already over. In the Urals high mountains were formed in the late Early Permian while intense preceding shortening of the crust terminated in the middle of the Carboniferous. Using this constraint the mean force acting in the lithosphere in areas which are located near to sea level can be estimated as 3×10^{12} Nm. The forces produced by the above mechanism increase with the altitude of the topography. In such regions as the Tibetan Plateau, Pamir and Southern Tien-Shan they can be as large as (5-7)$\times 10^{12}$ N/m. Depending on the boundary conditions, the forces can be compressive or tensile.

Most of the present mountain ranges and high plateaus were formed due to a rapid crustal uplift during the past several million years. The main cause was infiltration of mantle fluids into the lithosphere (Artyushkov, Russian Geology and Geophysics, 2012, 53, 561-577). In a presence of fluids, subcrustal lithosphere was strongly weekend. This ensured its convective replacement by the asthenosphere in many regions, which underwent strong Neotectonic uplift without intense shortening of the crust, e.g. in Central Asia and Western North America. Infiltration of fluids into the crust gave rise to low-grade metamorphism with the formation of hydrous minerals and rock expansion. This ensured a large input into the Neotectonic crustal uplift and was associated with the formation in some regions of low-velocity, low- viscosity and high conductivity layer within the crust. As a result of these processes, the elastic layer in the crust was reduced to 5-10 km with additional stresses reaching $\sim$1 GPa and existing for $\sim$1 Ma.