Geophysical Research Abstracts
Vol. 14, EGU2012-1133, 2012
EGU General Assembly 2012

What drives the Tibetan crust to the South East Asia? Role of upper mantle density discontinuities as inferred from the continental geoid anomalies

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The Himalaya-Tibet orogen formed as a result of the northward convergence of India into the Asia over the past 55 Ma had caused the north south crustal shortening and Cenozoic upliftment of the Tibetan plateau, which significantly affected the tectonic and climatic framework of the Asia. Geodetic measurements have also shown eastward crustal extrusion of Tibet, especially along major east-southeast strike slip faults at a slip rate of 15-20 mm a-1 and around 40 mm a-1. Such continental scale deformations have been modeled as block rotation by fault boundary stresses developed due to the India-Eurasia collision. However, the Thin Sheet model explained the crustal deformation mechanism by considering varying gravitational potential energy arise out of varying crustal thickness of the viscous lithosphere. The Channel Flow model, which also suggests extrusion is a boundary fault guided flow along the shallow crustal brittle-ductile regime. Although many models have proposed, but no consensus in these models to explain the dynamics of measured surface geodetic deformation of the Tibetan plateau. But what remains conspicuous is the origin of driving forces that cause the observed Tibetan crustal flow towards the South East Asia. Is the crustal flow originated only because of the differential stresses that developed in the shallow crustal brittle-ductile regime? Or should the stress transfer to the shallow crustal layers as a result of gravitational potential energy gradient driven upper mantle flow also to be accounted.

In this work, I examine the role of latter in the light of depth distribution of continental geoid anomalies beneath the Himalaya-Tibet across major upper mantle density discontinuities. These discontinuity surfaces in the upper mantle are susceptible to hold the plastic deformation that may occur as a result of the density gradient driven flow. The distribution of geoid anomalies across these density discontinuities at 220, 410 and 660 km depth in the upper mantle beneath the Himalaya-Tibet has been studied by analyzing the geoid undulation data obtained from various satellite geodetic missions along with the recent and old (EGM2008 and EGM2006) Earth Gravity models. Results show that the net geoid anomaly varies from -65 m to -20 m, which signify a density stratified upper mantle beneath the Himalaya-Tibet and the same has been confirmed from the results of regional seismic tomography studies. The density anomaly distribution beneath Tibet from 163 km depth to its upper mantle thickness of 1063 km show a strong NW-SE elliptically oriented positive geoid anomalies of magnitude around 40 meter. Asymmetric density anomaly gradient have been observed along the Himalayan arc from west to east as well as across the arc from north to south. This caused differential gravitational potential gradient and hence an elliptical flow structure of the Tibetan continental mantle along the resultant NW-SE direction, which is in concurrence with the observed present day direction of the Tibetan crustal flow. Thus the geoid anomalies distributed at various depth ranges show how the gradient in the upper mantle gravitational potential energy, especially across the deformed discontinuity surface, is significant in determining the transfer of deviatoric stresses and providing traction to the flow of crustal layers of the Tibetan Plateau. This suggests the viscous flow model could be a preferable choice, which could better accommodate the dynamics of the upper mantle, in explaining the crustal extrusion processes of the Tibetan Plateau.