# Modeling of Tibetan Dynamic Deformation with a Ductile Lower Crust

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We carried out three dimensional visco-elastic numerical modeling of the dynamics of the Tibetan Plateau by finite element method. Correct choice of rheology is critical to the success of the modeling. On one hand, the main body of the Tibet Plateau is in Airy isostasy, it usually implies that, like a block of ice floating on water, the crust is stronger than the upper mantle. On the other hand, it is suggested by rock experiments and EET studies that the lower crust of Tibet plateau is ductile and weaker than both the upper crust and the upper mantle beneath Moho. A paradox therefore is proposed: which is stronger? The lower crust or the upper mantle.

We found the lower crust has a low viscosity of $10^{17}$ Pas by modeling the post-seismic deformation of the Kunlun Ms 8.1 earthquake, November 14, 2001. We also make genetic algorithm – Finite Element stress inversion, i.e., trying to find out in what kind boundary actions and basal shears, the calculated stresses can best fit the observed stresses from the earthquake mechanism. The results suggest that the northeastern Tibet upper crust is subjected to a northeastwards basal drag, and the southeastern Tibet upper crust is subjected to a southeastwards basal drag, it implies a ductile flow of the lower crust, and the flow of the lower crust pulls the upper crust. GPS observations also find some parts of the Tibet plateau surface areas are in expansion. A north-south compression can produce east-west extension, but cannot produce surface area expansion; additional E-W extensional forces are needed to explain the expansion. The basal pull may provide such kind of forces.

However, why the main body of the Tibet Plateau is in Airy isostasy? Our calculation indicates that if the most ductile lower crust is enwrapped by strong crust or mantle limited in an area beneath the high plateau and cannot flow freely laterally, under long wave length load, the entire lithosphere, including the upper and lower crust with lithosphere mantle, together to support the load and reach isostasy. The paradox is therefore solved.

Viscosity is strongly temperature related, but geotherms in tectonic active regions cannot be deduced from steady state conduction solutions, therefore, we use seismic tomography data to calculate temperatures from seismic velocities. The thermal structure is controlled by heat advection due to the flat subduction of the Indian lithosphere beneath the Eurasia plate. Based upon such thermal and rheological structure, we made a three dimensional viscoleastic finite element modeling of the deformation of the Tibetan plateau under collision of the Indian plate. The model results fit the observation of GPS velocity and stress distribution from earthquake mechanism; it also interprets the uplift of the entire plateau and the clockwise rotation of the Plateau around the rapidly lifted eastern tectonic syntax.