The Tibetan plateau exhibits significant lateral variations of crustal structure, lithosphere thickness and temperature distributions (e.g., Wang, 2001; Klemperer, 2006). Accordingly, the study on the thermal state and strength of the continental lithosphere in the Tibetan plateau provides not only insights on the present-day geodynamics for this geologically intriguing landmass, but also information about the spatial variability of lithospheric rheology in this highly heterogeneous region.

The local isostasy analysis is used to constrain the lithosphere temperature distributions of the Tibetan plateau to avoid the difficult from the biased geographic distribution and intrinsic errors of some heat flow observations. Relative topographic variations, assuming local isostasy and taking into account density variations due to thermal expansion in the lithospheric mantle, can be used to constrain the vertical distribution of temperature within the lithosphere. Assuming local isostatic conditions, the absolute elevation of a given lithospheric column is determined by comparing its buoyancy force with that of the reference column at the mid-oceanic ridges. The geotherm calculation procedure adopts a five-layer model, consisting of a sedimentary layer (where present), an upper crust, an upper lower crust, and the lowermost crust, as well as, the lithospheric mantle layer. The heat production is assumed as stepwise distributions with depth (Wang and Sun, 2010). The thickness of crust and its sub-layers are obtained from a 1°×1° latitude-longitude grid crustal Vp model of China (Zhang et al., 2011). The mean elevation of each 1°×1° grid derived from the ETOP5 model is used as the fitting target in this study. The trial-and-error method is applied to search the surface heat flow value and obtain a minimum misfit of the elevation in each 1°×1° grid. Adopting estimates for tectonic strain-rates and thermal gradients at different depths provides a first-order description of the strength distribution within the lithosphere. For each depth interval strengths for both brittle and ductile deformation are calculated, with the lesser of these representing the limiting strength of the lithosphere at that particular depth level (Ranalli, 1995). A scalar measure for the total strength of a multi-layer lithosphere with a depth-dependent rheology can be obtained by vertically integrating the yield envelope. In this study, a four-layer model, consisting of an upper crust (wet quartzite), the upper lower crust (felsic granulite), a lowermost crust (mafic granulite), and the upper mantle (wet peridotite) is adopted; meanwhile, a steady-state strain rate of 10^-15 s^-1 is used. The relative crust strength for the Tibetan plateau, as the percentage of the crust strength to the integrated strength of whole lithosphere is calculated. Detailed descriptions on the methodology and the physical parameters adopted to reconstruct the geothermal gradients and rheological strength of the lithosphere can be found in Wang (2001) as well as Wang and Cheng (2012).

The thickness of the thermal lithosphere defined as the conductive layer above the adiabat with a potential temperature of 1300°C, is more than 120 km in the Tibetan plateau (Fig. 1). The lithospheric bulge in the eastern Tibet has thickness of 200 - 240 km. The thicker lithosphere (160 - 180 km) also occurs beneath the Tarim and the Sichuan basins.

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![Lithospheric thermal thickness beneath the Tibetan plateau and adjacent areas assumed to be the depth of the adiabat with a potential temperature of 1300 °C.](image)
However, the thinner lithosphere (<140 km) occurs beneath northern Tibet and the eastern margin of the Tibetan plateau (east of 100°E median). The lithospheric thermal thickness of the Tibetan plateau attained by this study is consistent with seismic studies (Klemperer, 2006; McKenzie and Priestley, 2008; Hu et al., 2011). The agreement between thermal modelling and seismic studies means that the geotherms constructed by the local isostatic equilibrium constraint are reliable.

The thick but warm lithospheres under the Tibetan plateau, and the Qilianshan fold belt correspond to the shortening caused by the convergence of the Indian and the Eurasian plate. The thickened lithospheric mantle can cause a disturbance to the rheologically stratified system, which induces Rayleigh-Taylor instability with the denser layer descending as a viscous drop and finally results in the convective thinning of the lithospheric mantle in convergent environments (Houseman and Molnar, 2001). According to seismic evidence, Houseman and Molnar (2001) suggested that the lithospheric mantle beneath the Tibetan plateau has undergone some form of instability that has led to asthenospheric replacement of some part of the lithospheric mantle, and the basaltic volcanism erupted since c.10 Ma, especially in the northern Tibet, also implies a thinner lithosphere in the northern Tibet. Therefore, the results of our geothermal modelling confirm the argument that the current structure of the lithosphere beneath the Tibetan plateau is a snapshot of the early stages of lithosphere instability.

The lateral distribution of the integrated yield strength of the lithosphere and the relative strength ratios of the Tibetan plateau are shown in Figure 2 and 3. It is shown that the lithospheric strength is lower than \(2 \times 10^{12} \text{ Pa m} \) within the Tibetan plateau, due to its over-thickened crust and elevated geotherm. The percentage of the crust strength to the integrated strength of the entire lithosphere across the majority of Tibetan plateau is larger than 90% (Fig. 3), corresponding to a stronger crust, but a weak upper mantle. This means that the present-day rheology of the Tibetan plateau belongs to the typical “crème-brûlée” layering. Previous studies point to the weak (<1\( \times 10^{13} \) Pa m) strength of the “crème-brûlée” layering as being earthquake-prone (Wang, 2001; Wang and Cheng, 2012). Accordingly, the high intensity of seismic activity in the Tibetan plateau is determined by rheological characteristics of the lithosphere. Meanwhile, the existence of weak lower crust and upper mantle beneath the Tibetan plateau favors the “channel flow” model of the large-scale deformation (Klemperer, 2006).

In summary, the geothermal modelling constrained by local isostatic equilibrium shows that the Tibetan plateau is characterized by a warm and thick lithosphere, the thickness of the thermal lithosphere is more than 200 km beneath eastern Tibet and the Qilianshan fold belt, meanwhile, the lithosphere is less than 140 km beneath northern Tibet and the eastern margin of the Tibetan plateau. The thick and hot lithosphere under Tibet plateau results from the uniform thickening of the crust and lithospheric mantle; moreover, the thin thermal lithosphere under the northern Tibet indicates the onset of convective thinning. The lithospheric rheology of the Tibetan plateau...
is approximated by the “crème brûlée” layering model, characterized by a strong crust with a weak upper mantle. The results provide a more robust approximation to the thermo-mechanical structure of the lithosphere of Tibetan plateau.

**Key words**: rheology; geotherm; local isostasy; lithosphere; Tibetan plateau

**References**


