Lithospheric SH wave velocity structure beneath the northeastern Tibetan plateau from Love wave tomography

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Introduction

The Cenozoic collision between the Indian and Eurasian plates has resulted in the formation of the Tibetan plateau in current stage. The modern plateau is characterized by high elevation with flat-topped and steep-sided morphology. Convergence and deformation continue today, but the mechanisms responsible for the plateau’s uplift remain under debate. Previous studies suggested that the high topography could result from either a highly thickened upper crust through brittle faulting and folding or ductile flow and inflation of the lower crust, or deep-seated thermal buoyancy due to the delamination or convective removal of tectonically thickened lithospheric mantle. The question of whether upper crustal thickening, the crustal flow or mantle lithospheric dynamic process is responsible for the height in northeast (NE) Tibetan plateau remains obscure: the isotopic assumption and do not consider the effect of anisotropy. Given above mentioned ongoing debates, in this study we construct a high-resolution SH wave velocity (VSH) model from Love wave tomography based on the dense seismic array ChinArray II and the permanent China Digital Seismic Array in the NE Tibetan plateau (Figure 1). Our current high-resolution VSH model could provide more details and could offer a line of additional independent evidence on the existing controversies.

Methods

Phase velocity inversion

• Earthquake two-plane-wave tomography for the periods of 20-100 s (Li and Li, 2015)

Shear wave velocity inversion

• Invert shear wave velocity from Love wave phase velocities using the method of Sato (1988)

Data

Fig. 2 Distribution of the echolocation system (red circles) used in this study. The black triangles indicate the course of the seismic array.

Resolution tests

Fig. 4 Example of checkerboard resolution tests for the synthetic shear wave model. The magnitudes of the input anomalies are 1% and 2% of the amplitude, and 1% and 2% of the amplitude, respectively, are chosen at 300 km.

Phase velocity of Love wave

Fig. 5a-c Phase velocity anomaly relative to the lower left corner in the 3D model. The phase velocity is estimated from Love wave using the method proposed by Sato and Fujiyama (1983). Each anomaly shown is clipped for the 30% upper mantle corner in Figure 1.

Summary

• Widespread zones of low wave speed at mid-lower crustal depth is observed beneath the NE Tibetan plateau. The reduced shear wave speed could be attributed to partial melt in the crust.
• Slow SH wave velocity is also observed in the uppermost mantle of northeastern Tibetan plateau, indicating a warm and weak lithosphere. This slow velocity could result from asthenosphere upwelling after lithospheric mantle removal in the NE Tibetan plateau. The consequence of the asthenosphere upwelling is the occurrence of partial melting in the mid-lower crust and a portion of high topography in this region via deep-seated thermal buoyancy after delamination.
• Fast SH wave velocity appears in the western Qilian range from the surface to the depth of 130 km, implying that the lower crustal channel flow model probably does not work in this region.

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