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Receiver function structures beneath the deep large faults in the northeastern margin of the Tibetan Plateau

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ABSTRACT

Using the teleseismic P- and S-wave receiver functions of the dense linear temporary seismic array, the crust and uppermost mantle structures beneath the deep large faults in the northeastern margin of the Tibetan Plateau were imaged. The images of the first converted wave and the multiples indicated that the North Fault Zone of West Qinling (NWQ) Mountain and Diebu–Lueyang (DBL) faults cut the Mohorovicic (Moho) Discontinuity and cause an obvious difference feature for the Moho in the two sides of the faults. The higher *Vp*/*Vs* ratio and lower velocity layer is found beneath the west portion of the array near the Tibetan Plateau, which implies a lower crust channel flow coming from the Tibetan Plateau. The weak Moho and higher *Vp*/*Vs* ratio beneath the eastern portion of the array near the Ordos suggest the upwelling of the hot mantle material. The results also indicate an obvious deformation in the upper crust with the lower *Vp*/*Vs* ratio beneath the middle of the array. Such upper crust deformation is closely related to the topography of the surface; therefore, we deduce that the deformation of the brittle upper crust is accompanied by the formation of the local topography during the uplift of the Tibetan Plateau, which is also the primary reason for the active seismicity in the study region. The deformation of the lithosphere–asthenosphere boundary (LAB) can also be associated with the formation of the diapir caused by the upwelling hot materials in the upper mantle due to the uprising of the thrusting plate caused by the subduction of the India Plate. The existence of the lower crust channel flow, the crust shortening, and the mantle diapir in the local region simultaneously implies that the elevation and formation of the Tibetan Plateau cannot be explained with a single model. The higher resolution results for the crust and the mantle, especially beneath the block boundary region, are necessary to construct the completed geodynamic model to understand the formation of the Tibetan Plateau.

1. Introduction

The formation and elevation of the Tibet Plateau, which arises from the ongoing collision of the India Plate and Eurasia Plate (Zhang et al., 2012), are always attractive research topics for geologists and seismologists. The information from topography and deep structure analysis supplied the important data to construct the model of the Tibetan Plateau that has been formed and maintained, i.e., the lower crust flow (Royden et al., 1997), the crustal shortening (Dewey and Burke, 1973), the underthrusting of the Indian Plate (e.g., Beghoul et al., 1993; W.P. Chen et al., 2012; Y. Chen et al., 2012; Kumar et al., 2006), and its modified version. Recently, many broadband seismic arrays have been deployed in the Tibetan Plateau to explore the internal structure. The results from the tomography and receiver functions of the multiple-international experiment INDEPTH (INternational DEep Profiling of Tibet and the Himalayas) gave direct evidence to help understand the collision of the Indian and Eurasian Plates (Y. Chen et al., 2012; Kind et al., 1996; Kosarev et al., 1999; Lei et al., 2009; Li et al., 2008; Makovsky and Klemperer, 1999; Nelson et al., 1996; Qian et al., 2007; Ross et al., 2004; Tian et al., 2005; Tilmann et al., 2003; Wu et al., 2005; Zheng et al., 2007; Zhou and Murphy, 2005). The seismic results (Kind and Yuan, 2010; Royden et al., 2008; Shen et al., 2011) suggest that the hot mantle material was squeezed by the direct lithospheric collision into the easterly and northeasterly directions. A 3-D shear wave model (Yang et al., 2012) from Rayleigh wave phase velocity maps based on the continuous observations of ambient seismic activity indicates that there are significant apparently interconnected low shear velocity features across most of the Tibetan middle crust at depths of between 20 and 40 km. Such a low velocity layer even extends to the northeastern margin of the Tibetan Plateau. The magnetotelluric imaging (Bai et al., 2010) also revealed that there are two major zones or channels of high electrical conductivity in the crust, and these zones extend more than 800 km from the Tibetan Plateau into southwestern China. This result also supports the hypothesis that warm mantle flows escape into the eastern

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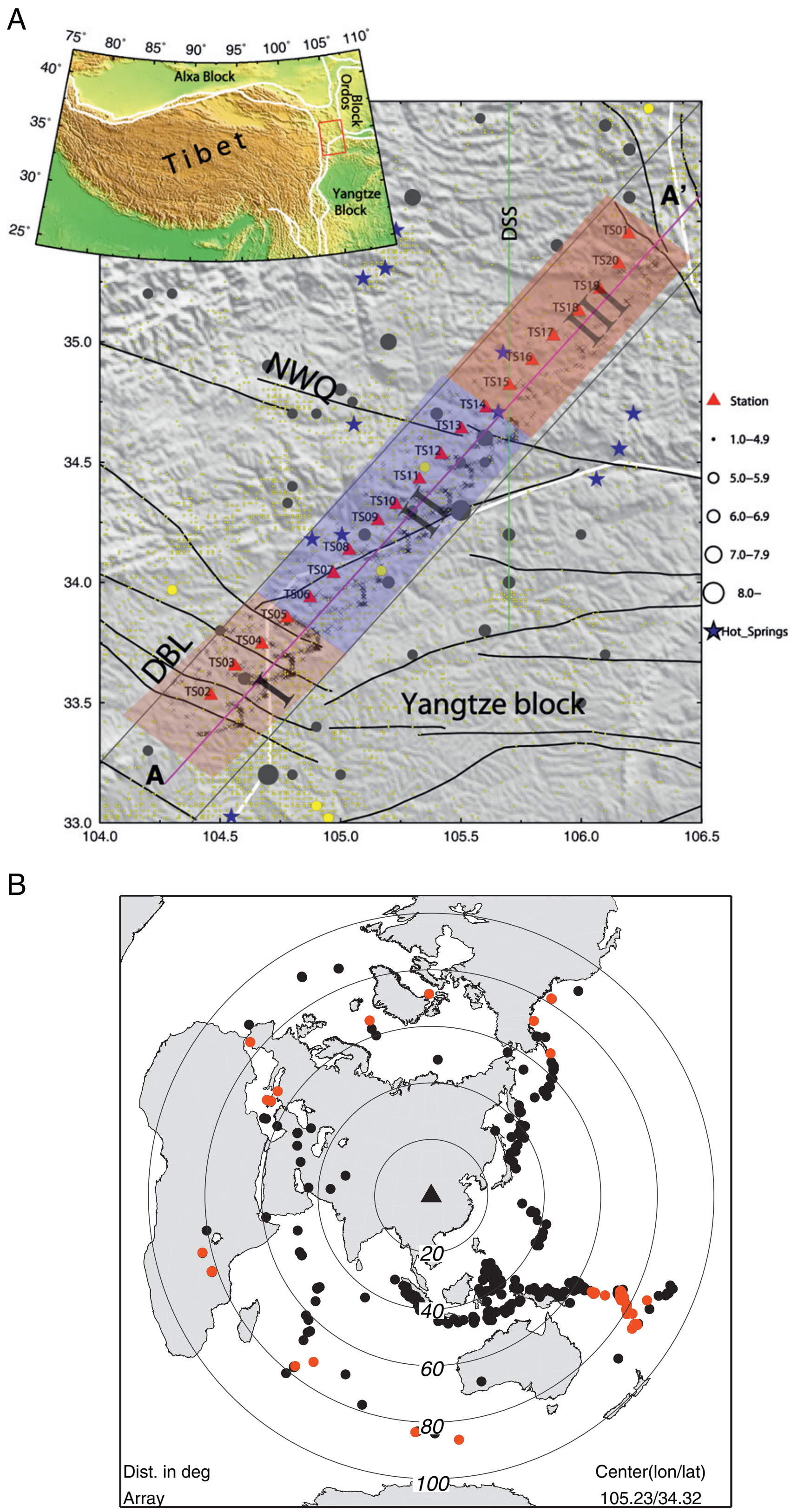

Fig. 1. The map of stations and events. (a) Locations of the seismic stations in the study. Red triangles denote the seismic stations; the letters beside them are the names of stations. Black crosses represent the pierce points of the Pms phase. The black lines represent the major active faults. DBL — Diebu–Lueyang faults; NWQ — North Fault Zone of West Qinling Mountain. The green line represents the DSS profile. Circles represent the earthquakes that have occurred in the history of the area. Gray and yellow colors indicate events before and after 1970. The size of the circle shown in the right of figure represents the magnitude of earthquake. The blue stars represent the hot springs with the temperature more than 50 °C. The small figure on the top left shows the background of the area studied. The wider white solid lines denote the boundary of the first grade block. The red quadrilateral is our study region. The letters are names of the blocks around the study region. The translucent shadow divides the study region into 3 units (I, II and III) according to the shape of the PRFs. (b) The distribution of earthquakes used in this paper: the triangle is the centroid location of the seismic array, and the points are the event locations. The red points represent the events of S receiver functions.