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Upper Mantle Discontinuity Structure underneath the Eastern Border of the Tibetan Plateau

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I. Introduction

The Tibetan plateau is considered as a laboratory of studying the ongoing large-scale continental deformation. At the eastern border of the Tibetan Plateau, the Yangzi block and the stable Sichuan basin blocked the eastward movement of the Tibetan Plateau, causing the crustal and upper mantle materials to deform strongly and change its movement to the south and northeast direction. Hence, the eastern border of the Tibetan Plateau is a key area for understanding the dynamics process of the building of the Tibetan Plateau. Up to now, many geophysical and geological surveys have been carried out near the eastern border of the Tibetan Plateau to explore the subsurface structures, deformation towards its geodynamic process. However, the role of crust and upper mantle played in the dynamic process of the collision between the Yangzi block and the Tibetan plateau is still not clear. To study the fine crust and upper mantle structure underneath the eastern Tibetan Plateau border, the dense Western Sichuan Seismic Array (WSSA) was deployed in the region of western Sichuan. In this study, we investigated upper mantle discontinuity structure underneath the eastern border of the Tibetan Plateau using the data from the WSSA.

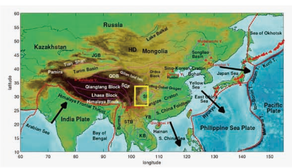

Fig. 1 Topographic map of East Asia with the tectonic units showing the relationship between the Tibetan Plateau and the Sichuan Basin(SB) and the Yangtze Craton. The yellow box indicates the studying area in this work. (Figure edited from Li et al, 2010)

II. Stations and Data

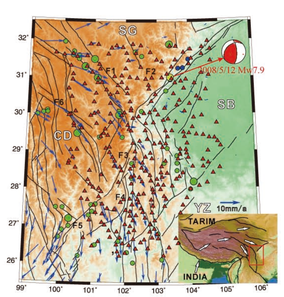

Fig.2 Geological settings and station map of the WSSA. SB: Sichuan basin; SG: Songpan-Ganze terrane; CD: Chuandian fragment; YZ: Yangze craton

The WSSA Array:

No. stations: 297
Freq. Band: 20Hz ~ 60 sec
Average station spacing: 20~30km
Observation Period: Dec. 2006 ~ Apr. 2009

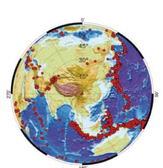

Fig.3 Distribution of teleseismic events used in this study

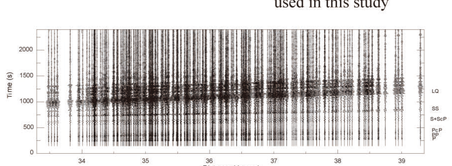

Fig.4 Verticle component of the waveform of the 2007/01/21 19:27:45.06 Mw7.3 Malacca (1.065N,126.282E) earthquake recorded by the array

III. Method and Data Processing

1. Receiver Function Estimation

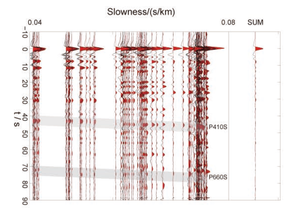

Fig. 5 Receiver function for station KKD03 varying with slowness. The receiver function is estimated with multi-station MMLD method (Liu et al.,2004) and SVD filtered (Freire and Ulrych, 1988).

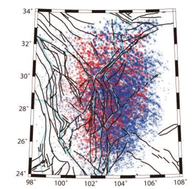

Fig.6 Distribution of PS piercing points at 400km (red) and 660km (blue) discontinuity

2. Common Conversion Point Migration

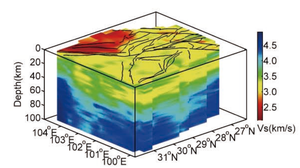

Fig.7 The crustal reference model is from the results of joint inversion of receiver function and ambient noise dispersion (Liu et al., 2010), IASP91 velocity model is used for depth larger than 100km.

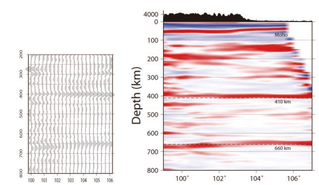

Fig.8 Waveform stacking and resulted imaging of the crust and upper mantle discontinuities. The stacking radius at the depth of 660km is 110km.

V. Summary

We investigated upper mantle discontinuity structure underneath the eastern border of the Tibetan Plateau in order to understand the role crust and upper mantle played in the dynamic process of the collision between the Yangzi block and the Tibetan plateau. We analyzed the receiver function data and imaged the upper mantle discontinuity structure by a common conversion point stacking technique. We used the 3D S-wave velocity model by joint inversion of receiver function and seismic ambient noise as the reference model up to the depth of 100km.

Our result shows that the 410 km discontinuity underneath the eastern border of the Tibetan Plateau is located at 400km depth with slightly decrease of less than 5km to the west. While the depth of the 660 km discontinuity increases from 650km under the Yangzi block to 670 km under the Chuandian block. Hence the thickness of the mantle transition zone (MTZ) varies from 250 km underneath the Yangzi block to 265 km under the Chuandian block. Our result infers obviously lower MTZ temperature (up to 200 K) under the eastern border of the Tibetan Plateau, which is consistent with high MTZ velocity anomalies from varies seismic tomography studies.

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IV. Results

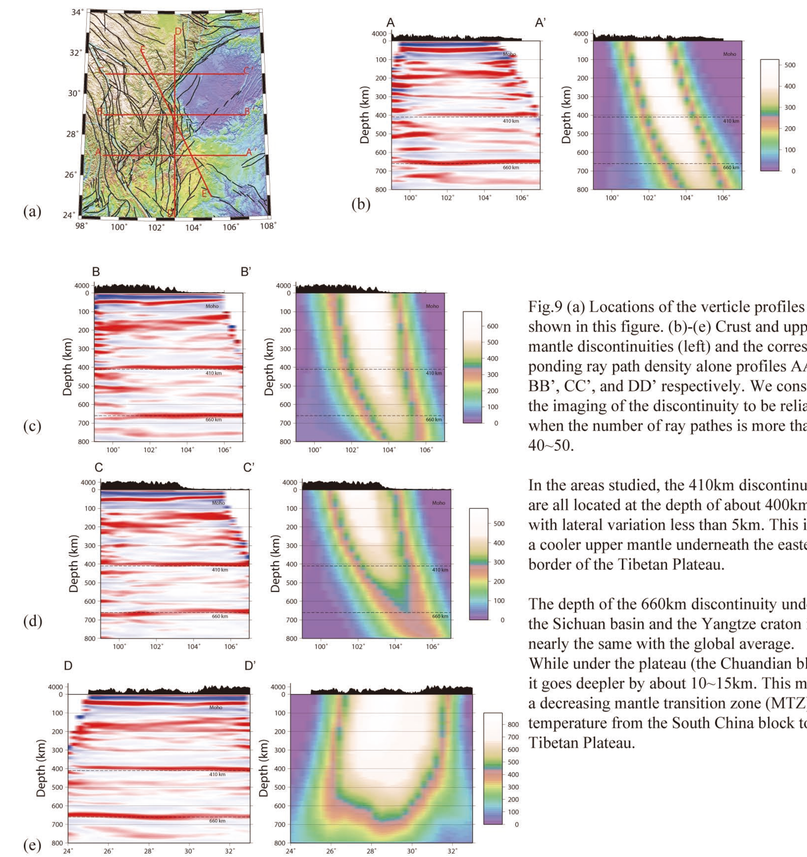

Fig.9 (a) Locations of the verticle profiles shown in this figure. (b)-(e) Crust and upper mantle discontinuities (left) and the corresponding ray path density alone profiles AA', BB', CC', and DD' respectively. We consider the imaging of the discontinuity to be reliable when the number of ray pathes is more than 40~50.

In the areas studied, the 410km discontinuities are all located at the depth of about 400km, with lateral variation less than 5km. This infers a cooler upper mantle underneath the eastern border of the Tibetan Plateau.

The depth of the 660km discontinuity under the Sichuan basin and the Yangtze craton is nearly the same with the global average. While under the plateau (the Chuandian block), it goes deeper by about 10~15km. This means a decreasing mantle transition zone (MTZ) temperature from the South China block to the Tibetan Plateau.

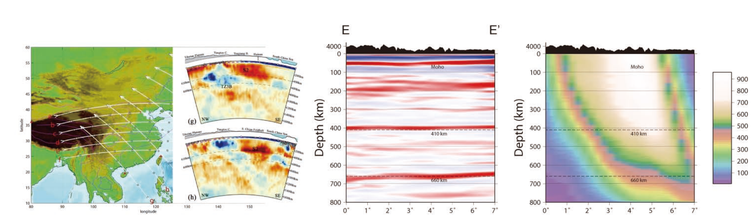

Fig.10 comparison of the mantle discontinuity alone profile EE' with seismic tomography results (Li et al., 2010). The lower temperature upper mantle is consistent with the high velocity anomaly found in the eastern border of the Tibetan Plateau.