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Crustal structure along the Zhenkang–Luxi deep seismic sounding profile in Yunnan derived from receiver functions

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ABSTRACT

The crustal thicknesses and the Poisson's ratios under the seismic stations can be calculated by receiver function method with H-κ stacking effectively. But the stacking results are affected to some extent by the average crustal P-wave velocity. To eliminate this effect and get more accurate crustal structure along the Zhenkang–Luxi deep seismic sounding profile which lies in Yunnan Province, we calculate the receiver functions from the teleseismic events recorded by 11 temporary stations as well as 5 permanent ones along the profile and carry out the stacking with Vp obtained from the profile in this study. Our study shows that the crustal thicknesses along the Zhenkang–Luxi profile range from 34.8 km to 41.8 km with an average of 39 km. The crust is thicker in the middle part of the profile and thinner in both sides in general. Dramatic changes of crustal thickness about 3 km are detected across both the Lancangjiang fault and the Xiaojiang fault, which implies that these faults cut through the Moho. The lowest Poisson's ratio under the stations is 0.22 and the highest is 0.27 with the mean of 0.25, which is lower than the global average value 0.27 in the continental crust. It suggests that most of the crust along the profile lacks mafic component, but contains more felsic substance. The low Poisson's ratio also indicates that there is no satisfying condition for partial melting. We deduce that the material flow in the middle-lower crust in the southeastern margin of the Tibetan plateau may occur only in the north region of 24°N.

1. Introduction

Yunnan Province, which lies to the southeast of the Tibetan Plateau, is located in the junction of the Tibetan Plateau terranes region, the Yunnan-Burma terranes region and the south China terranes region [1]. This area is obviously characterized by the developed deep fracture zone and frequent earthquakes, and the crustal structure is very complex [2,3]. It's important to understand the seismic activity and the background of strong earthquakes in this region by the deep research of the crustal structure. Affected by the collision between the India plate and the Eurasian plate, the Tibetan Plateau is strongly squeezed to the north with the uplift of the plateau and the thickening of the crust. As the passage of the lateral extrusion and the escape of the plateau material, or the channel of the middle-lower crust flow, Yunnan has attracted wide attention from researchers in the field of geosciences for a long time [4–6]. The deep study on the crustal structure in this area is helpful to reveal the deformation pattern and geodynamic process of the Tibetan plateau.

In recent decades, scholars at home and abroad have carried out a lot of research work in Yunnan and its adjacent areas, and achieved fruitful results. GPS measurement results show that the Tibetan plateau material encounters the hard South China block in the process of the eastward migration and then continues to move southeast, which makes the Sichuan-Yunnan region move clockwise around the East Himalaya syntaxis [7,8]. The results of seismic sounding, surface wave tomography, body wave tomography and ambient noise tomography disclosed the existence of the low velocity layer in the study area [9–12]. Receiver function studies find that the crustal material in some areas may be partially melted [13,14]. The results of magnetotelluric sounding indicate that there are some low-resistivity anomalies beneath the southeast of the

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Tibetan Plateau, and Bai et al. further propose that there are two channel flows in the middle-lower crust [15,16]. In addition, gravity measurements, anisotropy analyses and other researches are adopted in this region [17,18]. The previous studies lay the foundation for understanding the tectonic background. However, due to the difference of methods, data or models, there are still some contradictories existing in the results as well as controversies about the movement pattern of the Tibetan Plateau material. For example, high crustal Poisson's ratio cannot be observed in all of the areas where the middle-lower crust flow is supposed to exist. Therefore, further study of the crustal structure in this region is necessary.

Receiver function is a very effective method to study the structure of the earth's crust. It can obtain the crustal thickness and the Poisson's ratio from the teleseismic data. However, the crust thickness and Poisson's ratio calculated by the receiver function are affected by the average P wave velocity (V_p) of the crust to some extent [19,20]. In 2010, China Earthquake Administration (CEA) launched the project of China Seismic Array-the southern section of north-south seismic belt. Through the project, 350 broadband seismic stations were deployed in the southeast of the Tibetan Plateau, covering Yunnan Province, and a large number of high-quality teleseismic waveform data were recorded by these dense seismic stations. At the same time, the Geophysical Exploration Center, CEA carried out a high-resolution deep seismic sounding profile from Zhenkang to Luxi and obtained the crustal velocity structure along the profile. In order to get more accurate crustal structure information, in our receiver function study we would like to select the data recorded by 11 temporary stations from the China Seismic Array and 5 permanent ones from China National Seismic Network [21] along the seismic sounding profile and use the V_p obtained from the Zhenkang–Luxi profile (Fig. 1).

2. Regional geologic setting

Yunnan Province is located at the junction of the Tethys Himalaya tectonic domain and the circum-Pacific Ocean tectonic domain. In the collision and compression between the India plate and the Eurasian plate, the deep faults developed in the region and the geological structure is very complicated. The main faults in the study area include the Nujiang fault, the Lancangjiang fault, the Red River fault and the Xiaojiang fault (see Fig. 1). These large-scale strike-slip faults have undergone multi-period activities of the continental collisions and the terranes' merging [17,22].

The Red River fault lies in the central part of the study area. Taking the Red River fault as the boundary, the west part of the region should belong to Gondwana in tectonics and the east part belongs to the Yangtze block [13]. The Nujiang fault zone is a group of arcuate structural belts, which lies in Mainland China and is close to the India plate. Ophiolite has been found near the fault zone [11,13]. The Lancangjiang fault is a suture of continental collision. In the study area, these two faults divided the western part of the Red River fault into three different tectonic units, which are Tengchong, Baoshan and Simao block from west to East. Among them, there are Cenozoic volcanoes distributed in the Tengchong block. The Xiaojiang fault is the most active left-lateral slip in the study region [22]. The fault determines the margin of the secondary block in Central Yunnan in company with the Red River fault and the NE trending Lijiang fault. The secondary block is a part of the Sichuan-Yunnan

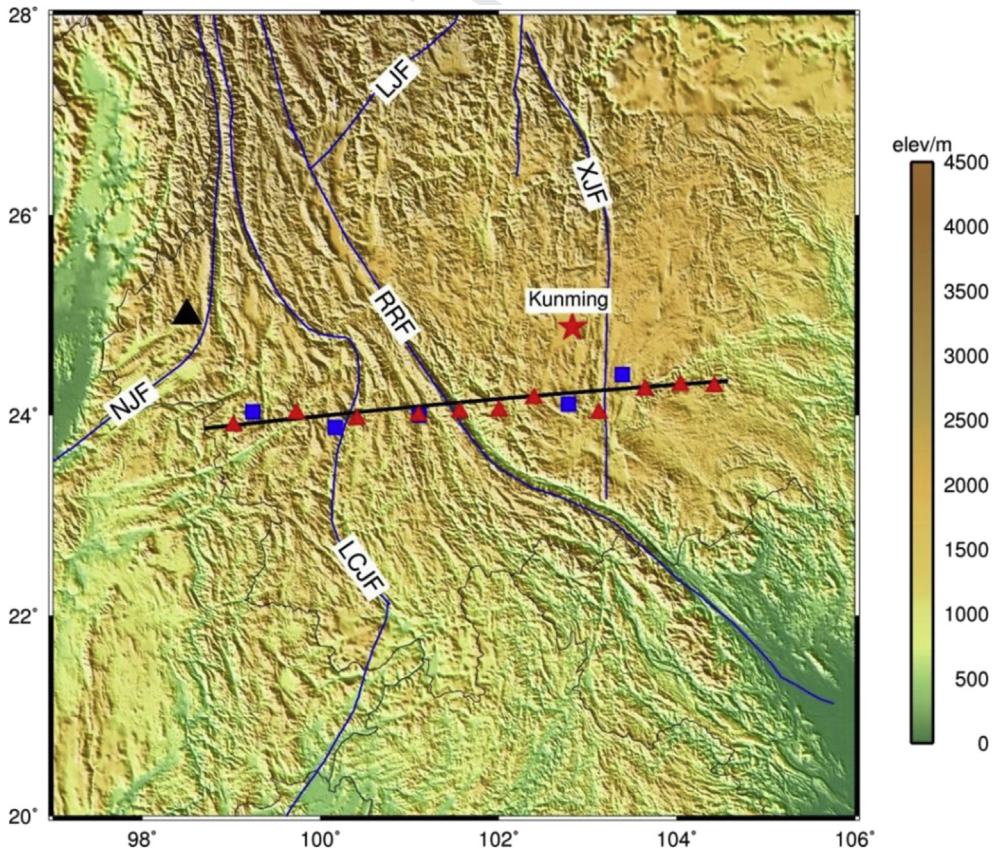

Fig. 1. Distribution of the main faults in the study region and the locations of the stations. The red triangles denote the temporary stations; the blue squares denote the permanent stations; the black line represents the deep seismic sounding profile from Zhenkang to Luxi; the black triangle indicates the Tengchong volcanoes. NJF – the Nujiang fault; LCJF – the Lancangjiang fault; RRF – the Red River fault; XJF – Xiaojiang fault; LJF – the Lijiang fault.