Journal of Asian Earth Sciences 37 (2010) 286–291

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

journal homepage: www.elsevier.com/locate/jseaes

Moho depth variation in Taiwan from teleseismic receiver functions

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ARTICLE INFO

Article history:
Received 6 March 2009
Received in revised form 20 August 2009
Accepted 27 August 2009

Keywords:
Receiver function
H–κ stacking
Crustal thickness
Taiwan

ABSTRACT

We determine lateral variation of Moho discontinuity, crustal thickness, and Vp/Vs ratios in the vicinity of Taiwan by analyzing all the available teleseismic waveform data collected by the Broadband Array in Taiwan for Seismology network from 1998 to 2004. The crustal thickness and the average crustal Vp/Vs ratio beneath each station are obtained by stacking Ps, PpPs and PpSs + PsPs phases coherently. The best estimated crustal thickness of Taiwan from 27 broadband stations is 30 km on average. The thinnest crust (11–15 km) is found east of the Longitude Valley suture zone, as part of the oceanic crust of the Philippine Sea plate. In other places, the crustal thickness varies from 17–19 km in northern Taiwan to 32–39 km in the southwestern island. The deepest Moho is found to be 53 km beneath station SSLB in central Taiwan. The average crustal Vp/Vs ratio in Taiwan is 1.74, with higher values of 1.74–1.99 in the north and lower values of 1.60–1.74 in the south. The crustal thickness variation is supported by gravity measurements in Taiwan and indicates that the collision between the Philippine Sea plate and Eurasian plate in Taiwan involves the whole crust. The thin crust and high Vp/Vs ratios in northern Taiwan are believed to be related to the volcanism in Tatun and Keelung located in the southwestern extent of the Okinawa Trough.

1. Introduction

Taiwan is located at the junction of the Ryukyu subduction system in the north and the Manila subduction system in the south (Fig. 1). It is believed that the active orogeny in Taiwan was generated by the collision between the Eurasian continental plate and Philippine Sea plate since Cenozoic (Lin and Watts, 2002). There are several models proposed to explain the tectonic development of Taiwan (e.g. Suppe, 1981; Hsu and Sibuet, 1995; Wu et al., 1997; Teng and Lin, 2004; Lin et al., 2003; Sibuet and Hsu, 2004), including the thin-skinned tectonics (Suppe, 1981) and the lithospheric collision model (Wu et al., 1997). In the past two decades, seismic tomographic studies provided the overall crustal structure of Taiwan (e.g. Roecker et al., 1987; Shin and Chen, 1988; Rau and Wu, 1995; Ma et al., 1996; Kim et al., 2005). The most recent tomographic study by Wu et al. (2007, 2009) confirmed crustal Vp structure in previous studies and provided better constraint on crustal Vp/Vs ratios. In their results, the Luzon volcanic arc is characterized as a belt of high Vp and high Vp/Vs at depths between 13 and 25 km. This high Vp/Vs belt can be traced to the subduction zone between Hualien and Ilan (from station HWAB–NANB in Fig. 1) in the deeper portion. The shallow portions of the southwestern coastal plain and the Pingtung region (from station WSSB to SCZB) are also characterized by a belt of high Vp/Vs, which may be caused by water-saturated young sediments. The study also suggests that there is a low Vp/Vs belt and a mountain root beneath the Central Ranges. However, due to sparse data, the crustal structure of the aseismic zones in the western foothill and central Taiwan is still poorly defined.

To derive velocity structure of deep crust and uppermost mantle for Taiwan, an alternative method called receiver function analysis is used in this study. The receiver function method provides high resolution information down to at least lithospheric depths by using teleseismic waveform data (Ammon, 1991; Langston, 1979). The interface between crust and mantle is often called the "Moho discontinuity", which exhibits a large acoustic impedance difference in seismic properties. Based on theoretical study (e.g. Phinney, 1964; Zhu et al., 1993), the P-to-S converted wave (Ps) generated at the Moho discontinuity will show dominantly on the radial receiver functions. We can utilize this Ps phase arrival time and amplitude to study the crustal structure and lateral variation of the Moho depth beneath Taiwan.

The first receiver function study in the Taiwan region was carried out by Tomfohrde and Nowack (2000) using frequency-band inversion of six short-period stations of the Taiwan Seismic Network (TSN). They provided a simple 1D crustal model beneath each station. The average Moho depth from all six stations is 38 km below sea level. Kim et al. (2004) showed that the average Moho

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doi:10.1016/j.jseaes.2009.08.015