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Short Note

Anomalous *Pn* Waves Observed in Eastern Taiwan: Implications of a Thin Crust and Elevated Oceanic Upper Mantle beneath the Active Collision-Zone Suture

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Abstract Normal *Pn* waves are commonly observed in Taiwan from shallow regional earthquakes at epicentral distances larger than 120 km, similar to the observations in many other continental regions. However, the critical distances to observe *Pn* waves for shallow eastern Taiwan earthquakes vary with azimuth corresponding to a significant variation of crustal thickness. In particular, anomalous *Pn* waves are commonly observed for shallow eastern Taiwan earthquakes recorded on seismic stations at epicentral distances as small as 60 km along the collision zone suture, the Longitudinal Valley. For the same event, normal *Pn* waves are observed at other seismic stations elsewhere on the island. The apparent velocity of the anomalous and normal *Pn* waves from the same event is 7.8 ± 0.15 km/sec, which is consistent with the average *Pn* velocity in the Taiwan area. Thus, the unusually short critical distance for *Pn* waves in eastern Taiwan suggests that the crust beneath the collision zone suture must be very thin and the upper mantle beneath the Longitudinal Valley must be relatively elevated compared with that beneath the other parts of Taiwan. Assuming a simple 1D layered velocity model, the Moho depth beneath the suture zone can thus be estimated at ~23 ± 2 km. This observation is consistent with the recent report from a high-resolution 3D tomographic inversion that a narrowly confined, anomalously elevated, and north-northeast–south-southwest elongated oceanic upper mantle was imaged beneath the Longitudinal Valley from Hualien in the north to Taitung in the south (Kim *et al.*, 2005, 2006). Furthermore, the preceding observations may also support the interpretation that the conduction of excess heat supply from the elevated hot oceanic upper mantle into the adjacent mid-to-lower continental crust over a long period of geological time may play an important role in the crustal deformation beneath the continent, including metamorphism, thickening, and uplifting.

Introduction

The Longitudinal Valley of central eastern Taiwan is sandwiched between the Central Range of the Eurasian plate and the Costal Range of the Philippine Sea plate (Fig. 1). It is considered as the collision suture between the two fast-converging plates (Ho, 1986; Tsai, 1986). The Longitudinal Valley extends for about 160 km along the north-northeast–south-southwest orientation with less than 10 km width in most places and is filled up with Quaternary sediments. The crust and upper mantle structure and their associated earthquake activity across the suture zone are the keys to our understanding of how plates interact and deform along an arc-continent collision between two active subduction zones. In the past decade, lateral variations of crustal structure and *P*-wave velocity beneath the Taiwan area were studied extensively by 3D tomography inversions of local earthquake data (e.g., Rau and Wu, 1995; Ma *et al.*, 1996; Cheng *et al.*, 2002, Kim *et al.*, 2005). To provide constraints on the uppermost mantle velocity around Taiwan, Ma and Song (1997), Huang *et al.* (1998), and Chen *et al.* (2003) analyzed travel times of the first *P* arrival (*Pn* phase) observed at epicentral distances in the range from 150 to 300 km. In general, the average *Pn* velocity in Taiwan region is about 7.8 km/sec (Yeh and Tsai, 1981) which seems to be slightly higher to the east and to the west of the Central Range (Huang *et al.*, 1998). Here, we report that anomalous *Pn* waves are observed at stations with epicentral distances as small as 60 km