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Polarity Reversal of Active Plate Boundary and Elevated Oceanic Upper Mantle beneath the Collision Suture in Central Eastern Taiwan

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Abstract The active collision between the Eurasia and Philippine Sea plates in eastern Taiwan has been explored from the recently determined 3D velocity images and relocated hypocenters. A north-northeast–south-southwest-trending high-velocity zone corresponding to the oceanic upper mantle is narrowly defined underneath the collision suture from Hualien to Taitung. This elevated and hot oceanic upper mantle must have played an important role in the tectonic evolution/mountain-building process of the adjacent continental crust. A northwest-dipping seismic zone can be identified in the northern collision zone extending from the surface to ~30 km depth, which can be correlated with the northern Longitudinal Valley Fault (LVF). This zone marks a transitional plate boundary separating the high V_P and high V_P/V_S oceanic crust to the east and the high V_P and V_S upper crust and low V_P and low V_P/V_S mid-to-lower continental crust to the west. A significant amount of plate convergence along the suture has been accommodated by the high-angle thrusting along the northern LVF. In contrast, a southeast-dipping seismic zone can be identified extending from the surface to ~25 km depth near Taitung in the southern collision zone. This zone coincides with a region of high V_P and high V_P/V_S, suggesting that earthquakes occurred within a highly fractured or fluid-rich zone. The reverse polarity of active-plate boundary faults marks two distinguished transition boundaries, one from eastward subduction in southern Taiwan to east–west collision in the southern collision zone corresponding to the early phase of plate collision, and the other from east–west collision to northwest subduction in the northern collision zone corresponding to the advanced phase of plate collision. The central collision zone is creeping and aseismic, which can be attributed to the high heat flow and geothermal activity during an interseismic period since the 1951 Taitung earthquake.

Introduction

Located along the plate boundary between the Eurasia (EUP) and the Philippine Sea (PSP) plates, the island of Taiwan was formed as a consequence of an arc-continent collision. Deformation and seismicity in and around Taiwan are very active because of the high-convergence rate between the two plates (Yu *et al.*, 1997). The PSP is subducting beneath the EUP in northeastern Taiwan along the Ryukyu trench, while the South China Sea plate, a subplate of the EUP, is subducting beneath the PSP in southern Taiwan along the Manila trench. Active collision is taking place between the two subduction systems in central eastern Taiwan. The Longitudinal Valley (LV), sandwiched between the Central Range (CR) of the EUP and the Coastal Range (COR) of the PSP, is considered as the collision suture between the two plates (Ho, 1999; Tsai, 1986). The LV is about 160 km long and less than 10 km wide in most places and is filled with Quaternary sediments. The LV is bounded by two north-northeast–south-southwest-trending faults running parallel to each other from Hualien in the north to Taitung in the south. These two bounding faults can be roughly delineated from the topography (Fig. 1), although their surface exposures are rarely seen because of the high-erosion rate and thick sediment cover. Because the PSP converges obliquely toward the EUP, the collision in the northern LV near Hualien is far more advanced than that at the southern LV near Taitung where the collision is in its early stage. The eastern boundary of the LV, the Longitudinal Valley fault (LVF), is a very active high-angle oblique thrust fault with a minor left-lateral strike-slip component (Barrier and Angelier, 1986; Yu *et al.*, 1990; Yu and Kuo, 2001; Yu and Liu, 1989). The LVF can be subdivided into several smaller fault segments including, from north to south, the Luehmei fault

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