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Mantle faulting and intra-slab stress heterogeneity revealed by the 2006 earthquake doublet in the northern Manila subduction zone

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We investigated the 2006 Pingtung (southwestern Taiwan) offshore intraslab earthquake doublet (~Mw 6.9), striking around the northern Manila subduction zone, where transitional crust subducts. The two main shocks were at the depth below the local MOHO (~30 km), and occurred ~8 minutes apart. These two events, as reported by GCMT and USGS catalogues, have high non-double couple components, indicating their complex source characteristics. The proposed source models of past studies are not in good agreement; therefore, the ambiguity of the sources invites further investigations. Additionally, their specific mantle-depth location and the stress heterogeneity within the slab revealed by the doublet are yet to be explained. In this study, we first use depth phases of the doublet to constrain their depths. The main asperity, of these two events are located at about 37 and 55 km depth, respectively. With this constraint, we next apply the potency density tensor inversion method using teleseismic body waves to resolve the source models. This method allows variations of focal mechanisms on the modeled plane so that the complex source characteristics can be flexibly included. In the first event, the normal component dominates, but the modeled waveforms systematically fit better with the observations if we include a thrust-faulting nearly simultaneously occurring beneath the normal faulting. The second event is characterized by a predominant strike-slip component, with variations in fault geometry and a deeper location. We also found that the background seismicity in the surrounding region is also layered with normal, thrust, and strike-slip mechanisms. The layered occurrence of all these mechanisms within the confined region implies drastic variations of σ1 along the depth. We invoke geodynamic models to investigate the local stress regime in the subducted slab. To satisfy the slab morphology at the Northern Manila subduction zone, it requires a weak upper crust and a strong lower crust for the subducting plate. The dynamic model indicates that σ1 is enhanced below MOHO as the transitional crust subducts and the slab bends. Due to the bending, σ1 oriented vertically at about ~40 km depth and oriented horizontally at ~50 km depth. The model explains our observations of variations in focal mechanisms along the depth. This study solves the complex seismic source model within a transitional slab. It reconciles the short-term seismic observations with the long-term geodynamic model, revealing stress regimes in a specific tectonic setting and their potential effects on the source process.

Keywords: Northern Manila subduction zone, 2006 Pingtung offshore doublet, source complexity