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Geological structure and active deformation in the fold-thrust belt of southern Taiwan in relation to crustal-scale structure

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The fold-thrust belt of southern Taiwan currently accommodates rapid westward shortening in the order of 4.5 mm/a and is estimated to have developed since the Late Pliocene. It is the locus of the 2016 M_w6.4 Meinong earthquake, which involved fault slip at multiple levels in the mid-to-upper crust. It nucleated at ~15 km depth and also triggered shallow structures that reach the surface or nearly. To characterize the structure of the piedmont and investigate the broader tectonic setting of the event, we build two east-west regional balanced cross-sections based on surface geology, subsurface data, coseismic and interseismic geodetic data, and published nanno- and magneto-stratigraphy. We also document the first-order evolution of the piedmont and how the piedmont structures relate to the inner part of the mountain belt based on the cross-section restoration and the analysis of the seismic velocity structure of the plate boundary.

From the Coastal Plain towards the east, we propose a series of three active west-dipping backthrusts, rooted on a ~4.0-km-deep detachment, the Tainan detachment. The detachment lies within the base of the 3-km-thick Plio-Pleistocene Gutingkeng mudstone, which represents the initial foreland basin sediments. Syntectonic sediments and rapid shortening and uplift observed from geodetic measurements attest for the activity of these structures since the Late Pleistocene. Further east, the Tainan detachment ramps down to ~7 km depth, allowing the east-dipping Lungchuan and Pingchi thrusts to bring Upper Miocene continental-shelf formations to the surface. The cross-section restoration indicates less than 10 km shortening since ~450 ka or less on the Tainan detachment and the frontal backthrusts, while the east-dipping Lungchuan and Pingchi thrusts each consumed ~10 km shortening. Another ramp from ~7 to ~11 km depth is expected further east based on older sediments and slates exposed on the hanging wall of faults in the inner part of the mountain belt. This ~11-km-depth detachment seems to correspond with an inversion in seismic velocities at ~12 km depth beneath the slates belt, interpreted as slates over-riding lower-velocity passive margin sediments. Therefore, the detachment and thrusts system proposed from our cross-section appears to correspond to the main plate interface, where

significant shortening was consumed in a thin-skinned deformation style, involving only foreland basin sediments near the deformation front.

The Meinong earthquake coseismic surface deformation suggests that, in addition to the deepest (15-20 km) main fault plane, the ~4-7-km-depth ramp, the Tainan detachment and the backthrusts slipped aseismically during after the earthquake. In contrast, the earthquake nucleated below the main detachment and, based on tomographic models, there is no clear structural connection between deep and shallower structures. The Meinong event locates near the interface between Cenozoic basement rocks and post-rifting sediments, similarly to the 2010 M_w6.3 Jiashian event. We propose that this interface is the locus of moderate-magnitude events, which seismic waves triggered limited slip on shallower faults, rooted within the weak, fluid-rich Gutingkeng mudstone. This interface may have developed as a secondary detachment level with limited total shortening.