

Inferring Plate Boundary Deformation Mechanisms from Lithospheric Structure and Stresses around Taiwan

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Abstract

Oblique convergence between the Luzon arc on the Philippine Sea plate and the Eurasian continental margin is associated with a progressive termination of collision in northern Taiwan as well as subduction of the Eurasian plate underneath the island. It has long been recognized that one model for this flipping of subduction polarity beneath Taiwan is the progressive tearing of the Eurasian plate along the continental margin. Global tomography combined with local tomography near Taiwan images the torn subducted edge of the Eurasian slab to be roughly 250 km NW from the continent's edge, underneath the Eurasian continental shelf. In addition, this tear does not propagate into the overlying crust, implying that the continental margin underneath the collisional mountain belt subducts by delamination. Further, 3D stress-orientations estimated from focal-mechanisms show significant differences between the deep and shallow stress field near Taiwan, reflecting two different deformation styles. At depths greater than ~ 20 km, plate convergence is mainly taken up by subduction and plate flexure with little deformation, whereas plate convergence at shallower depths is consumed by strong orogenic deformation. These two levels of the lithosphere are largely detached. Specifically, deep stresses within the Philippine Sea plate – within ~ 50 km of the plate interface – show an EW orientation roughly normal to the plate interface. This EW orientation is significantly different from both the absolute and relative (convergent) plate motion, and possibly reflects the dominance of interface mechanics. In contrast, the shallow stresses (0-20 km) in southern and central Taiwan mountain belt are very commonly (but not universally) parallel to the surface displacement field. This contrast in shallow and deep stress fields is especially strong in central Taiwan. The largest principal compressive stresses in the subducting Ryukyu Slab are oriented EW (i.e., strike-parallel) near its contact with the Eurasian lithosphere up to depths of ~ 120 km. The along strike compression supports previous inferences of buckling based purely on seismicity. In contrast, the flattening of the Ryukyu Slab east of Gagua Ridge (inferred from tomography) is accompanied by along-dip principal compressive stresses, indicating the Ryukyu Slab is sufficiently rigid to act as a stress-guide.