Geodynamic Subduction Models Illuminate Seismotectonic Stress Indicators

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Ambient stress fields associated with subduction processes are revealed by seismotectonic stress indicators such as earthquake focal mechanisms. Insight into the origins of these stress fields can be gained through analysis of simplified geodynamic models representing major components of relevant regional subduction regimes. Here we illustrate how such geodynamical modeling can illuminate some of the driving factors behind seismic stress indicators in several regions.

Down-dip extension in the subducting Sunda plate reflects incipient arc-continent collision between the Palawan continental fragment and the Philippine Mobile Belt, accompanied by increases in slab dip and tensional plunge, with increasing approach to collisional locking, from north to south along the southern Manila Trench to Mindoro Island. This extension may be enhanced by interaction of the slab tip with the thermally uplifted olivine → wadsleyite phase transformation (Bina et al., 2020).

Deep seismicity in the subducting Nazca plate, including large 2015 events beneath the Peru-Brazil border, indicates down-dip compression in a steeply dipping region near 600 km depth, in agreement with geodynamical modeling of Nazca subduction and slab stagnation (Zahradník et al., 2017).

Geodynamical modeling of the subducting Pacific plate beneath the Japan Sea and eastern China suggests that down-dip compressional stresses arising from buoyant and viscous forces are augmented by slab bending and unbending stresses, so that down-dip compressional seismicity may trace the upper and lower surfaces of the slab in the respective bending and unbending regions (Čížková et al., 2020).

Deep seismicity beneath Tonga shows a down-dip compressional stress regime undergoing a transition to vertical extension below ~680 km depth. This could arise from juxtaposition of positive petrological buoyancy just above the thermally depressed ringwoodite → bridgmanite + ferropericlase transition with negative thermal buoyancy just below this phase boundary. However, geodynamic models suggest that these stresses may be significantly overprinted by slab bending stresses, so that the observed stress transition may also be related to tightening of a fold during slab stagnation (Pokorný et al., 2023).

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