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Strain Partitioning Between the Slab and the Upper Plate: Implications for the Deformational Efficiency of Subduction

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The conventional view of plate boundary strain during the seismic cycle in subduction zones portrays the accretionary margin and upper-plate wedge as the primary site of intra-seismic strain accumulation and co-seismic strain release. This textbook model provides a mechanism for tsunamigenesis, and the accumulation of residual deformation over numerous cycles produces the observed upper plate deformation. In general however we know little about the nature of this strain partitioning and the associated efficiency with which the subduction cycle permanently deforms the upper plate. In fact there is accumulating evidence that along some subduction segments, the subducting slab may be the dominant player in hosting the elastic strain accumulation and release during the seismic cycle. A series of recent great subduction earthquakes is allowing us to investigate this intra-seismic strain partitioning, and begin to identify the spectrum of strain conditions seen in subduction zones. In particular, the 2006/2007 pair of great earthquakes along the Kurile trench, the 2007 Solomon Islands great earthquake, and the 2009 Samoa/Tonga great earthquake point to there being a significant variability in intra-seismic strain accumulation and co-seismic strain release among various subduction systems (and likely even along different rupture segments of the same trench). One implication of this variability is that the permanent deformation within the accretionary wedge and upper plate, driven by residual (inelastic) strain accumulating during the seismic cycle, likely varies significantly in both space and time. Inferences of the nature of slab/wedge coupling derived from observations of upper plate deformation are thus suspect. Young subduction systems with minimal amounts of total subduction may provide the best environment to observe and constrain the linkage between plate boundary kinematics and upper plate deformation.