Residual topography and gravity anomalies reveal characteristic structure of tsunami earthquake zones

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Tsunami earthquakes are shallow, long-duration events that are depleted in short-period energy and produce larger tsunami than expected given their surface wave magnitudes. Although most explanations for these characteristics invoke weak materials on the shallow megathrust, no unique feature of subduction environments has been linked to their occurrence and tsunami earthquakes have occurred in regions with large sedimentary wedges, no sedimentary wedge, rough and smooth subducting plate bathymetry, and a wide range of convergence rates and plate ages.

We have applied spectral averaging routines to suppress the steep topographic and gravitational gradients across all subduction zones on Earth. This processing shows that tsunami earthquakes tend to occur in regions where the outer-forearc is steep (~5°), narrow (slope break within 60 km of trench) and morphologically rough/faulted. This characteristic structure is observed in nearly all tsunami earthquake zones and along-strike reductions in outer trench-slope gradient in Peru, Nicaragua, Hikurangi and NE Japan all coincide with transitions from tsunami to more typical megathrust earthquakes.

We suggest (1) a stronger basal fault is required to generate these steep wedges, and (2) the slip behavior of this shallow segment is different from its downdip neighbor. It can be strong when it is locked and the downdip region creeps. It can be strong(er) when the downdip region ruptures. For each configuration, compression of the frontal wedge may promote reactivation of out-of-sequence thrust faults, which in some regions may play a key role in tsunamigenesis. We will describe our observations within this framework and consider physical explanations for the along-strike variability implied by tsunami earthquake distributions and residual bathymetry anomalies.

Keywords: Tsunami, Earthquake, Subduction

