Sediment Pathways Across Trench Slopes: Results from Numerical Modeling

**MOTIVATION**

Until the 2011 Mw9.0 Tohoku earthquake, the role of giant tsunami earthquakes and tsunamis as agents of sediment dispersal and accretion across erosional trench slopes was under-appreciated. Decades of seismic reflection surveys and sediment coring did document a general sedimentation pattern: Trench-parallel accretionary sediments accumulate across the trench slope as a slope apron less than 1 km thick, whereas sediments at the trench axis are either accreted to the small frontal wedge, or reworked (1). A series of studies carried out after the 2011 earthquake and tsunami revealed a variety of unappreciated sediment dispersal mechanisms, such as tsunami-triggered sheet turbidites (2). Furthermore, new piston cores collected across the trench slope indicate significant along-trench and across-trench variability in the way that sediments were mobilized by the 2011 event. Hence, the combined dataset suggests that giant earthquakes and tsunamis may be important agents for dispersing sediments across the trench slope.

To complement these new observational data, we modeled the pathways of sediments across various trench slopes (1, 3, 4, 5, 6, 7).

**RESULTS (1, 2, 3, 4, 5, 6, 7)**

**JAPAN TRENCH**

Most pathways issued from the shelf and upper slope terraces near the top of the small frontal wedge, and thus do not reach the trench axis. In turn, sediments transported to the trench axis are mostly derived from the small frontal wedge or from the subducting Pacific plate. These exist very few direct pathways from the shelf areas to the trench. These results are consistent with existing seismic profiles across the trench slope (2), which showed that the slope apron does not extend as far as the frontal wedge, and that the sediment fill in the trench is surprisingly thin (similar to the sediment cover on the incoming plate).

**OTHER TRENCHES (1, 2, 3, 4, 5, 6, 7)**

The same method has been applied to Cascadia Trench (3), Middle America Trench (4), and Sunda Trench (7). These other trenches with adequate multibeam bathymetric coverage. Although local minima may act as potential barrier to sediments from the upland areas, the overall pattern appears to be more uniform. For the Cascadia and Middle America trenches (3, 4), sediments from the upper slope can readily find pathways to the trench through the numerous canyons. Some slope basins on the accretionary prism (Cascadia) or narrow frontal wedge (Costa Rica) are isolated from the canyon-dRAINAGE systems. Their sediment fill is thus likely to be locally-derived. Turbities in these isolated basins may record seismic activity only associated with storm activity or local earthquakes. This would make them ideal targets for paleoseismological studies.

**COSTA RICA**

For the Sunda Trench (7), only few canyons provide pathways to the trench axis and slope basins must be fed by locally-derived sediments.

**METHOD (3)**

Pathways are modeled based on the assumption that transport directions are simply controlled by the slope apron.

The algorithm we developed comprises the following steps:

- Median filter (width: 1000 m) is applied to bathymetric grid.
- Slope apron is derived from the bathymetric grid (2).
- Modeled pathways initiate at arbitrary positions arranged on a regular grid pattern (red dots in (5), yellow dots in (7)).
- Successive downstream positions are extrapolated in the direction of slope apron at distance increment of 600 m - 1000 m.

The optimal distance increments were determined by trial-and-error. However, they are compatible with the transport behavior of turbiditic flows, which may step over 1 km-scale obstacles.

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Arai et al., Geology 2014

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Fujiwara et al., Science, 2011