Very Fine Grained-, Very Coarse Grained-, and Internally Stratified-Tsunami Deposits: Geologic Constraints on Flow Conditions.

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Abstract:

End-member tsunami deposits from prehistoric and historic events in the Central Cascadia margin, USA are examined for application to placing constraints on tsunami flow parameters. Very-fine grained deposits of tsunami organics and silt are defined here as tsunami debris layers. These organic-mud-rich layers extend well beyond the reach of tsunami sand sheets, as recently demonstrated for prehistoric tsunami in Cannon Beach, Oregon, and for the Dec. 26, 2004 tsunami runups in SE India. Due to very-low settling rates, the tsunami debris layers (TDL) extend to maximum inundation distance, and in appropriate, proximal settings they also record maximum runup elevation. A case study from the central Oregon coast is presented to show maximum runup elevations (~10 m MSL) of paleotsunami in the central Cascadia margin for the last 3,000 years.

Tsunami and sheet deposition has been widely assumed to originate from suspension transport and deposition. However, patchy sand distribution, bluff body shadows, water traps, and internal cross-bedding in some sand sheets argue for transport and deposition by bedload entrainment. To test this argument we have employed high-frequency GPR to image the internal stratification of three sand sheet deposits produced by the historic far-field tsunami (1964 Alaska source) in Seaside, Oregon. The GPR profiles demonstrate plane bedding (critical flow) in the 40 cm thick HORN sand sheet, low-index ripple cross-stratification (subcritical flow) in the 5 cm thick 12^{TH} sand sheet, and chaotic mound deposition (supercritical flow) at 0-20 cm thick PLUM sand sheet. Measured flow depths and observed flow velocities yield Fr values that are consistent with the imaged internal stratification at the three Seaside test sites.

Minimum values of tsunami flow competence can be established by the size, shape, and density of entrained clasts, and associated bottom roughness.

The largest entrained clasts can be used to place minimum constraints on bottom, critical shear stress (τ_c). The key to constraining critical shear stress rests with focused searches in source areas with very-large clasts. Damaged URM structures, beach rip-rap, and roadbed aggregate provided such sources for Dec. 26, 2004, runup sites in SE India and SW Thailand. In prehistoric settings of the Cascadia margin we are targeting cobble beach berms, abandoned cobble beach ridges, and cobble channel lags for sources of very-coarse clastics. A case study of boulder entrainment is presented for the 1700 AD Cascadia tsunami that poured-over an abandoned cobble ridge (1 km inland distance) at the south end of the Seaside, Oregon. Using a formulation $\tau_c = 0.039(\rho_s - \rho)\, g\, D_i\, 0.18\, D_{50}^{0.82}$ by Komar & Carling (1991) the 20 cm diameter boulder on sand yields a critical shear stress of 190 dyne cm^{-2} for this pour-over site.