Cascadia Supercycles: Evidence of Clustering and Holocene History of Energy Management From the Long Cascadia Paleoseismic Record

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The Holocene Cascadia earthquake series affords uncommon opportunities to examine recurrence models, clustering and long term strain history of a subduction zone. In addition to the time series of turbidites developed for Cascadia, new Chirp seismic reflection data image many of the correlated Cascadia turbidites investigated with core samples. These data image individual turbidites with a spatial resolution of ~ 25 cm. The reflection records reveal that the Cascadia seismites are not exclusively channelized, and directly image of proposed clusters and gaps on the basis of groupings of turbidites and the depth sections. Using the combined core and seismic data, we attempt to address the issue of energy management over multiple earthquake cycles through the temporal record of interseismic intervals and a proxy for magnitude of the earthquakes. Plate convergence between earthquakes is assumed to increase elastic strain energy in proportion to interevent time. We propose that coseismic energy may be modeled as proportional to the mass of turbidites triggered in seismic shaking. We infer that turbidite mass is a suitable proxy for energy release because of its consistency along strike at multiple sites. We scale turbidite mass (energy release) to balance plate convergence (energy gain) to generate a 10ka energy time series for Cascadia. The pattern reveals that the earthquake clusters apparent in the time series have variable behavior. Cluster 4 (~10000-8800 BP) maintains an even energy state before falling to a low after large event T16. Cluster 3 (~8200-5800 BP) climbs steadily in energy state until falling sharply to a similar low following large event T11. Cluster 2 (~4800-2500 BP) climbs then falls to a low after T6. Cluster 1 (~1600-300 BP) slowly declines from T5 to T1. What is apparent is that some events release less while others release more energy than available from plate convergence (slip deficit). Those that are larger may have borrowed stored energy from previous cycles. Cycle variations may explain mismatches between deformation models based on interevent times in the last 4600 years and coastal paleoseismic data. During that time, a long series of 8 earthquakes comprise a decline in energy state, yet some produced outsized tsunami relative to plate convergence alone. We suggest these events may be using energy from a previous peak at the time of T8, ~ 3400 years prior. The new reflection data image suggest that the oldest of our two clusters 3 and 4 comprise a larger cluster containing ~ 14-18 events, prior to which a long quiescent period occurred in the latest Pleistocene. Age control is insufficient to determine the length of earlier gap, however the presence of this gap firmly anchors the Cascadia clustering sequence.