Cascadia Great Earthquake Recurrence: Rupture Lengths, Correlations and Constrained OxCal Analysis of Event Ages

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We are continuing to test correlation methods for a series of offshore cores along the Cascadia subduction margin. The goal is to correlate paleoseismic event along strike to determine rupture lengths for 23 Holocene events. To refine the 14C time series, we are applying multiple proxies, including XRF analysis, to the determination of hemipelagic thickness between turbidite events. With improved sedimentation rates, and time intervals represented by inter-event sedimentation, we use Bayesian statistical methods to combine and constrain radiocarbon ages. Using OxCal we incorporate limiting ages with known criteria including ash ages, hemipelagic sedimentation rates, and historical data to refine the error ranges for a given event. Multiple ages for the same event are also given "credit" for this, and rather than averaging, iterative Bayesian models are used to reduce the error range for events that are known to correlate, and or have independent constraints. This method significantly reduces ^{14}C variability between along strike events that are thought to correlate.

We also refine inter-site physical property correlation methods in parallel with ^{14}C ages. Depositional patterns within events, recorded as magnetic susceptibility, chemical, and density patterns, match at widely separated sites in surprising detail. 16 individual event density-magnetic signatures between JDF and Cascadia Channel have correlation coefficients of 0.6-0.9, with two poor scores (0.16 and 0.32) for events with similar, but out of phase characteristics. The stratigraphic character of each event is clearly evident in the cores. In some cases, correlation of events hundreds of km apart is almost as robust as the correlation between piston and trigger core pairs only one meter apart. Numerical tests of the correlation patterns strongly support this conclusion. Values for other measures include: the number of sandy pulses per event down core($r=0.84$-0.92), relative thickness pattern downcore ($r=0.70$-0.89), and whether these values could have come from a random sample of a normal distribution (rejected with 99% confidence). Thus, both individual event signatures, and the downcore stratigraphy are both highly unique and strongly comparable from site. The techniques being used are standard well log correlation methods, applies to paleoseismology. We are just beginning to explore similar correlation with shallow marine records along the Vancouver Island outer coast with some success.

Strengthened correlations, refined ^{14}C ages, and closer correlation with land events support long rupture lengths for at least 16 great earthquakes in the Holocene, extending from at least 42N to 48N. Several partial ruptures are evident, four limited to southern Oregon, one from central Oregon northward, and one from central Oregon southward. The penultimate event at ~ 1500 AD, is recorded at all offshore sites as a thin turbidite, partially eroded by the AD 1700 event, and is apparently only recorded at one, or a few land sites, suggesting perhaps a small event. The size patterns of the correlated events are remarkably consistent, with large events being large at all sites, and small event generally small at all sites, with rare exceptions. The size patterns are abrupt, changing thickness from event to event, and do not have long term or intermediate term trends, suggesting that climate or sediment rate changes are not the cause. This suggests a link between earthquake magnitude and turbidite size, though there is no known way to quantify this relationship if present.

These paleoseismic results suggest that though Cascadia shows evidence of segmentation, the preferred rupture mode for events of at least M~ 8.0 or larger is for full or nearly full margin rupture.