"Paleoseismograms": Testing a Hypothesis of Source-Time Function Recording of Paleoearthquakes

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Abstract

The past occurrence of great earthquakes in Cascadia is now well established by both the coastal and turbidite event paleoseismic records. In the course of both offshore paleoseismic investigations, we have been using physical property signatures to aid in event correlation. We have found that it is possible to correlate individual turbidites from site to site using high resolution physical property data such as Gamma density, P-wave velocity and magnetic susceptibility. The magnetic and density “fingerprints” of each turbidite are a reflection of grain size distributions within each turbidite. It is the sequence of coarse units that we are correlating over large distances, using the same techniques used in the oil industry to “fingerprint” formations and track them through prospect fields. However the long distance correlations and level of detail possible are not well explained. It is difficult to explain the observation that individual events can be correlated in detail between separate channels and slope basins that are not connected. Some correlated events are as much as 500 km apart, yet they share basic characteristics such as event size, number of coarse sandy pulses, and even subtle details of the shape of the physical property signatures. To investigate this phenomenon, we generated turbidity currents in flume tanks, and triggered the currents with a set of inputs that simulated several input scenarios. We input initial perturbations similar to those expected from several recent great earthquakes, such as the 1906 NSAF earthquake, and the 2004 Sumatran earthquake, as well as generic signals and simulations of storm generated hyperpycnal flows. We used calibrated simulated sediment material, and used photographic techniques to extract detailed grain size plots of each turbidite deposit. When compared the input sources of the turbidity currents, we found that there is an excellent correlation between the input perturbations and the recovered grain size profiles of the deposits, reflecting considerable detail of the input source. We successfully simulated input perturbations of single and multiple input energy peaks of varying lengths and flow hydrographs, as well as simulated hyperpycnal flows, with consistent results across a wide range of timing and and parameter scaling variations. We conclude that turbidite records may record information about the triggering event. For earthquake sources, we suggest that a crude record of the source-time function of the earthquake may be recorded in the turbidite deposits. This hypothesis may explain the unusual correlation of isolated paleoseismic sites in Cascadia, the NSAF and Sumatra. If correct, turbidites under ideal conditions may record enough source information to be considered "paleoseismograms" recording information about paleo-rupture sequences on large fault systems. Data from turbidites found in land-locked inlets and sub-alpine Cascadia lakes are consistent with this experimental result

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