Third Generation Paleoseismology: Convolving Sedimentology with Site Analysis, Slope Stability and the Earthquake Source in Sub-aqueous Settings

Goldfinger, C.[1], Patton, J.R.[1] Morey, A.E.[1], Black, B.[1], Galer, S[1]., Nelson, C.H.[2] , Gutiérrez-Pastor, J. [2]

[1]*Oregon State University, College of Earth, Oceanic and Atmospheric Sciences, 104 Ocean Admin. Bldg., Corvallis, Oregon 97331, USA.* gold@coas.oregonstate.edu

[2]*Instituto Andaluz de Ciencias de la Tierra (IACT) CSIC-Univ. de Granada, Campus de Fuentenueva s/n 18002 Granada, Spain* odp@ugr.es

Third generation sub-aqueous paleoseismology is moving beyond event identification and dating, and to some extent beyond simply establishing long recurrence statistics. Long and detailed paleoseismic records afford uncommon opportunities to examine recurrence models, clustering, segmentation, interaction with other faults, long term strain history and paleo slip characteristics. Submarine paleoseismology is a multidiscipline endeavour, both requiring and benefitting from broad consideration of slope stability, drainages, source pathways, physiography and sedimentology to both test and develop an earthquake record from a sampling strategy that is commonly sparse. An important tool commonly unavailable in land paleoseismology is litho-stratigraphic correlation. Correlation of deposits over broad areas (relative to the size of the earthquake) is one key element (of many) in testing the stratigraphic record for earthquake origin. Detailed sedimentology alone is rarely enough to accomplish this task. Fortunately, well log correlation, a well-developed method, can be adapted to correlation of core samples. Many geophysical proxies such as CT and gamma density, and magnetic susceptibility can provide not only “wiggle” traces for comparison, but good grain size proxies that sometimes reveal very detailed structural similarities with deposits and deposit sequences over large as well as short distances. Although turbidite structure is commonly assumed to be controlled by hydrodynamics, we show that correlation across multiple environments can demonstrate that at least in the case of very large earthquakes, these effects can be overprinted with other factors, including earthquake source effects. Cores may be correlated between sites with continuous stratigraphy, and even between sites with no physical connection in some cases. In Cascadia, inter-site correlation has now been accomplished between deep marine sites in several settings, as well as both fjords and (tentatively) with onshore lakes with no physical connection to the deep water sites. Chirp seismic reflection profiles can be used to test for earthquake origin within lakes, and offshore between slope basins and by correlation of beds over very large distances. Other tests can be applied to test for synchronous origin, such as at channel confluences where provenance, flow direction and turbidite sequence and structure can be used to test for synchronous passage and deposition from turbidity currents far beyond the abilities of dating methods. As with all geologic methods, site selection is critical. Channelized turbidity currents may travel hundreds to thousands of km, but unconfined turbidity currents and their deposits may wane rapidly away from the source. Slope stability analyses typically show that relatively small earthquakes will generate slope failures. However, other factors such as the slip model of the earthquake, directivity, local physiography, and the “Q” distribution in the region of interest also likely factor into the distribution of interpretable deposits from

earthquakes.

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