Onshore-Offshore Correlation of Geologic Evidence for Great Cascadia Earthquakes--Permissive Agreement Between Washington Estuaries and Cascadia Deep-Sea Channel

Details

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Abstract

Geologic dating permits one-for-one correlation between coseismic subsidence in coastal Washington and turbidity currents in Cascadia deep-sea channel in the past 4000 years. The correlations make sense if plate-boundary rupture off the Washington coast accounts for the coastal subsidence. Such rupture would radiate seismic shaking directly beneath the submarine canyonheads that feed turbidity currents to Cascadia channel. The correlation strengthens the basis for using the turbidites as proxy records of great Cascadia earthquakes in the early Holocene, beyond the typical reach of the region's coastal subsidence records. For the past 4000 years in southwest Washington, the estuarine record of coseismic subsidence contains eight events at irregular intervals. The record can be seen at low tide as buried marsh and forest soils each capped with tidal-flat mud and some also coated with sand from tsunamis or sand blows. Successive soils differ consistently in stratigraphic patterns that provide field criteria for correlating among outcrops and for estimating relative lengths of recurrence intervals. The field correlations have survived chronological tests that include 32 sample ages with one-sigma counting errors less than 20 radiocarbon years. Most of these were measured on inner rings of the roots of earthquake-killed trees, from which the difference between sample age and event age can be counted with annual growth rings. Other materials set limiting ages that constrain event ages less exactly. Event age ranges at >95-percent confidence, in calendric years before AD 1950: 3550-4150 [8 events ago]; 3310-3390 [7]; 2845-2925 [6]; 2420-2620 [5]; 1540-1610 [4]; 1229-1264 [3]; 760-1190 [2]. The most recent event [1] dates from AD 1680-1720 (radiocarbon), 1699-1700 (ring-width patterns), and January 27, 1700 (Japanese documents). Well-defined intervals between successive events range from a few centuries [4 to 3] to a millennium [5 to 4]. One interval [7 to 6] approximates the mean of about 500 years. Radiocarbon dating provides limiting-maximum ages for five of the last eight turbidity currents in Cascadia channel. Two such limiting ages were measured for each of two turbidites [1, 6], and one age was obtained for each of three other turbidites [3, 4, 8]. Each sample age was measured on planktonic foraminifera that settled to the seafloor before the turbidity current arrived. The difference between the sample age and the event age depends largely on the depth of erosion (if any) by the current. For simplicity we assume no such erosion. In addition, using standard carbon reservoir corrections, we assume that the foraminiferal carbon had an initial age of 800 radiocarbon years. Resulting maximum ages for the turbidites, at two-sigma in calendric years before AD 1960: 3540-3840 [8], 2660-2840 [6], 1600-1830 [4], 1300-1460 [3], and 0-200 [1]. One-for-one correlation provides the simplest explanation for these findings. The correlation is violated only by the limiting-maximum ages for turbidites 1 and 6, which are slightly younger than the tree-death dates for subsidence events 1 and 6. The limiting age for turbidite 6 agrees better with a coastal event age if turbidite 6 correlates with coastal event 5. In that case, the coastal record is incomplete: turbidite 5 lacks an onshore correlative and divides the longest coastal interval (5 to 4). Stratigraphic evidence onshore and offshore casts doubt on this alternative interpretation.

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