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HOLOCENE TURBIDITE PALEOSEISMIC RECORD OF GREAT EARTHQUAKES ON THE CASCADIA SUBDUCTION ZONE: CONFIRMATION BY ONSHORE RECORDS AND THE SUMATRA 2004 GREAT EARTHQUAKE

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Marine turbidite stratigraphy (Goldfinger et al., 2003; Nelson et al., 2003), onshore paleoseismic records of tsunami sand beds and co-seismic subsidence (Atwater and Hemphill-Haley, 1997; Kelsey et al., 2002; Witter et al., 2003) and tsunami sands of Japan (Satake et al., 1996) all show evidence for great earthquakes (M $\sim$ 9) on the Cascadia Subduction Zone.When a great earthquake shakes1000 kilometers of the Cascadia margin, sediment failures occur in all tributary canyons and resulting turbidity currents travel down the canyon systems and deposit synchronous turbidites in abyssal seafloor channels. These turbidite records provide a deepwater paleoseismic record of great earthquakes (see also Gutierrez EGU, 2005). An onshore paleoseismic record develops from coseismic subsidence;by drowning forests on the coast and subsequent tsunami sand layer deposition. The recent Sumatra subduction zone great earthquake of 2004 and the 1700 AD Cascadia tsunami sand preserved in Japan (Satake et al., 1996) shows that ocean-basin wide tsunami deposits result from these great earthquakes, which rupture the seafloor for hundreds of kilometers.

The Cascadia Basin turbidites from multiple channel systems, provide the longest paleoseismic record of great earthquakes that is presently available for a subduction zone. A total of 18 synchronous turbidites have deposited along $\sim$600 km of the Cascadia margin during the Holocene time of $\sim$10,000 cal yr BP and 13have occurred since the Mt. Mazama eruption (7627 $\pm$ 150 cal yr BP)(Zdanowicz et al., 1999). Four other turbidites are more limited in extent to the southern Oregon margin. Because the first Mazama ash bearing turbidite marker bed was deposited $\sim$ 7200 years ago and the youngest paleoseismic event in all turbidite and onshore records (Satake et al., 1996) is 300 AD, the average recurrence interval of events is $\sim$ 575 yr, the same as that found in the longest onshore paleoseismic record (Witter et al., 2003). Linkage of the rupture length of these events comes from relative dating tools such as the "confluence test of Adams (1990), and from physical property correlation of individual event "signatures". We have two methods for obtaining a more detailed record of the paleoseismic recurrence history: ^{14}C ages and analysis of hemipelagic sediment thickness between turbidites (H), where H/sedimentation rate = time between turbidite events. Utilizing the most reliable ^{14}C and hemipelagic data sets from turbidites for the past $\sim$ 5000 yr, minimum recurrence time is $\sim$ 300 yr and maximum time is $\sim$ 1300 yr (Nelson et al., 2003). There also is a recurrence pattern through the entire Holocene that consists of a long time interval followed by one to three short intervals that is apparent as well in the coastal records.

Both onshore paleoseismic records and turbidite synchroneity for hundreds of kilometers, suggest that the Holocene turbidite record of the Cascadia Subduction Zone is caused dominantly by triggering of great earthquakes similar in rupture length to the Sumatra 2004 earthquake. The tsunami deposit of the1700 AD Cascadia event is estimated to result from a M 9 great earthquake that generated a tsunami 3 m high along the coast of Japan (Satake et al., 1996). Nanayama et al. (2003) show that historical earthquakes rupturing 100-200 km segments along the Kuril subduction zone bordering Hokkaido create tsunami deposits which extend less than 0.5 km inland from the beach; however, other pre-historic great earthquakes occurring about every 500 yr for the past 7000 yr, rupture much longer segments and create tsunamis greater than 5 m high that deposit tsunami sands more than 3 km inland. The 1700 AD and other great earthquakes of Cascadia for the past 7000 years also register an onshore record of significant coseismic subsidence and deposit tsunami sand beds along the entire Cascadia coast that extend inland as much as 10 km from the beach (Atwater et al., 1997, Nelson et al., 1995; Kelsey et al., 2002 and Witter et al., 2003). Because the ages of onshore paleoseimic events (Atwater et al, 2004) and recurrence patterns in general agree with the Cascadia turbidite paleoseismic record, and because the onshore Cascadia paleoseismic tsunami deposits are comparable to those created by great earthquakes in other subduction zones, the Cascadia onshore deposits also appear to reflect mainly a record of great earthquakes. Historic earthquakes that rupture smaller 100-200 segments occur frequently in other subduction zones (Nanayama et al., 2003; Sieh et al. 2004), but appear to represent only four of the events in the Cascadia paleoseismic record. The perceived lack of shorter rupture length segments, thus smaller magnitude earthquakes, implied by the Cascadia record may result because such earthquakes are not characteristic. The great earthquake tsunami deposits found around ocean basins (e.g. Japan 1700AD and Sumatra 2004), however, suggest that the similar tsunami deposits of Cascadia and synchronous turbidites for $\sim$ 600 km may mainly preserve the paleoseismic record of great subduction zone earthquakes (nearly full margin rupture) and miss the record of smaller magnitude (shorter rupture length) events. The short historical record of subduction earthquakes leaves this question clouded in most locations. Consequently, the turbidite paleoseismology methods developed for the Cascadia subduction zone should be applied to better define the great earthquake history of Sumatra and other subduction zones.

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