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Calibrating the Smallest Southern Cascadia Earthquakes with Historic Era Turbidite Stratigraphy

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Abstract Text:

Analysis of core stratigraphy at deep-water sites in southern Cascadia reveals a number of historic event beds that allow ground-truthed comparisons of the extent and characteristics of these event beds. Trinidad Canyon has a high-resolution record that captures much of the turbidity current material in a high-levee plunge pool. 7 replicate cores offer a detailed Holocene record of the main series of Cascadia turbidites and others interbedded with and overlying 1700 CE. 3 significant and 7 faint beds younger than 1700 CE are found. Depositional age models anchored by bomb-carbon and AMS ^{14}C ages show two beds with ages of ~1780 (1750-1810) and ~1830 (1800-1870). The third bed above 1700 CE is ~1870 (1830-1900) and could either be the 1861-62 major storm, or the 1873 slab earthquake. The fourth bed above 1700 is dated at ~1910 (1870-1940) and is likely the NSAF 1906 Mw 7.9 earthquake. Three faint beds lie between the ~1906 bed and the bomb ^{14}C beds. The three <1950 beds are ~1960 (1930-1980) ~1980 (1955-1996), and ~1990 (1972-1999). The upper two are significant, and are most likely associated with the 1980 Mw 7.2 Eureka and the 1992 Petrolia Mw 7.2 earthquakes. The ~1960 faint bed could be an earthquake nearby in 1959, or possibly the 1964 flooding event. We correlate the probable 1980 and ~1960 beds 155 km north, the probable 1992 and 1906 beds 140 km north, and the ~1922 bed 120 km north. The other faint beds cannot be traced outside the Trinidad Plunge Pool. From these results, we construct a triggering range vs Mw plot for turbidity currents large enough to leave observable beds in multiple systems, as follows: Mw=7.3: 120 km; Mw= 7.2: ~150-210 km; and Mw= 7.9: > 200 km. These approximate (and minimum) values allow refined consideration of the smallest Southern Cascadia turbidites attributed to the plate boundary by Goldfinger et al. (2012, 2017). We conclude that that previous rough magnitude estimates (Mw 7.5-8.4) for the smallest events that do not extend north of Rogue Canyon, and are not found in the tsunami record at Bradley Lake may be overestimated. Some of these events are similar in extent, thickness, mass and grain size to the event beds associated with the 1906, 1922, 1980 and 1992 (Mw 7.2-7.9) earthquakes. The origins of these event beds may include slab, crustal, or plate boundary earthquakes, and uncommonly, non-earthquake sources.

Plain-Language Summary:
Paleoseismic evidence of smaller Southern Cascadia earthquakes includes a turbidite record of events that is only partially observed onshore. The lack of onshore record is likely due to their lower magnitudes which are below the threshold needed to generate an onshore record. We observe several turbidite beds offshore that likely correspond to historical earthquakes in 1906, 1922, 1980 and 1992. These earthquakes of known magnitude can be correlated along the fault zone to help calibrate the southern Cascadia record by showing the extent of the known beds. We find that the historic earthquakes of magnitudes 7.2-7.9 are similar in extent and characteristics to the smallest earthquakes attributed to the Cascadia plate boundary. This means that the previous magnitude estimates were probably too large, and, and that the sources may include crustal, and slab earthquakes in addition to Cascadia plate boundary events.

Session Selection:
NH010. Geohazards in Marine and Lacustrine Environments

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Abstract Title:
Calibrating the Smallest Southern Cascadia Earthquakes with Historic Era Turbidite Stratigraphy

Requested Presentation Type:
Assigned by Program Committee (Oral, eLightning, or Poster)

Previously Published?:
No

AGU On-Demand:
Yes

Comments to Program Committee:
Prefer Oral presentation.

Abstract Payment:
Paid (agu-fm20-686505-2198-1827-6445-1663)

For non-students only: I am interested in receiving information on the Mentoring365 Live program.

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