# Cascadia Integrated Paleoseismic Records from Onshore and Offshore Core Data

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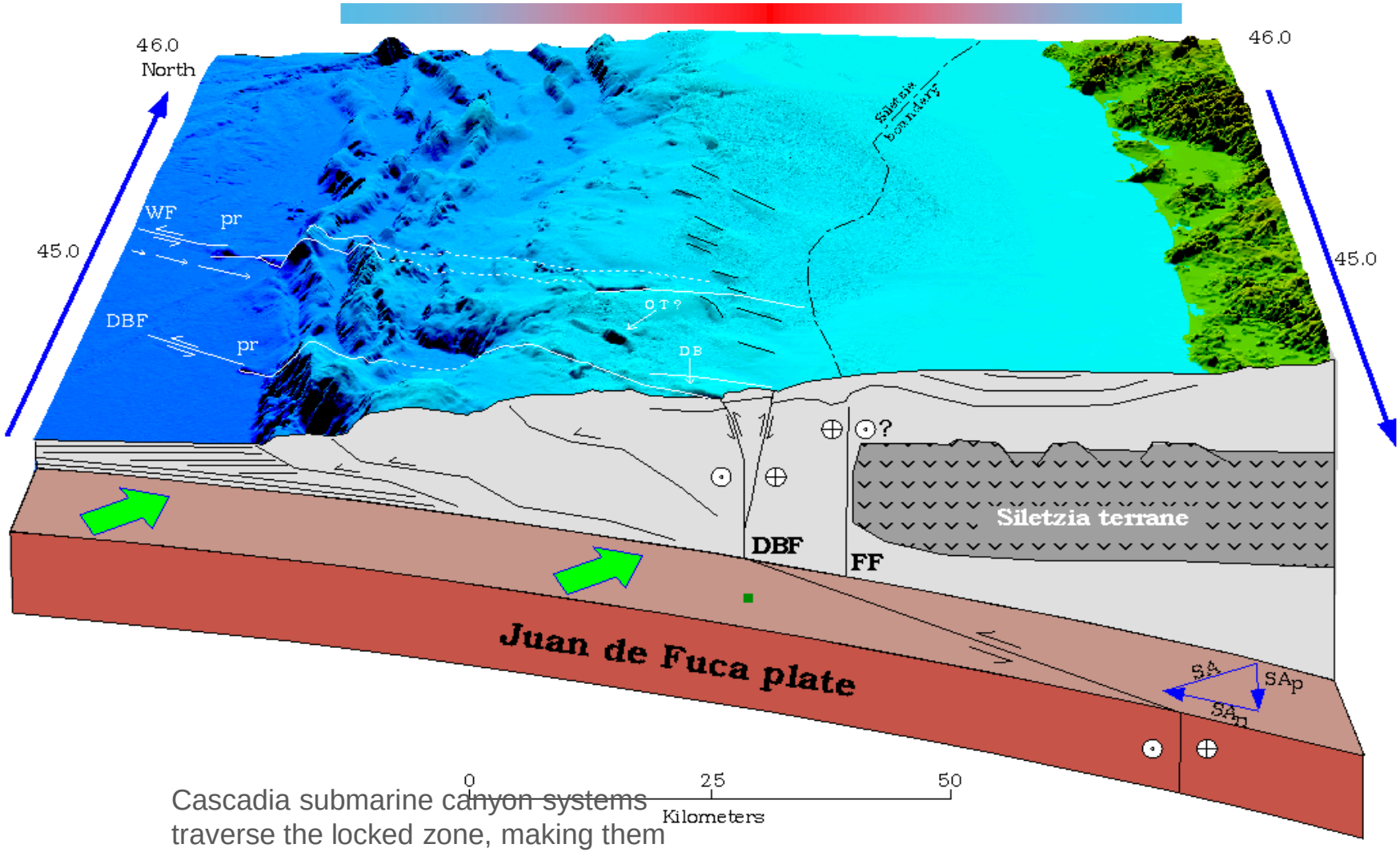
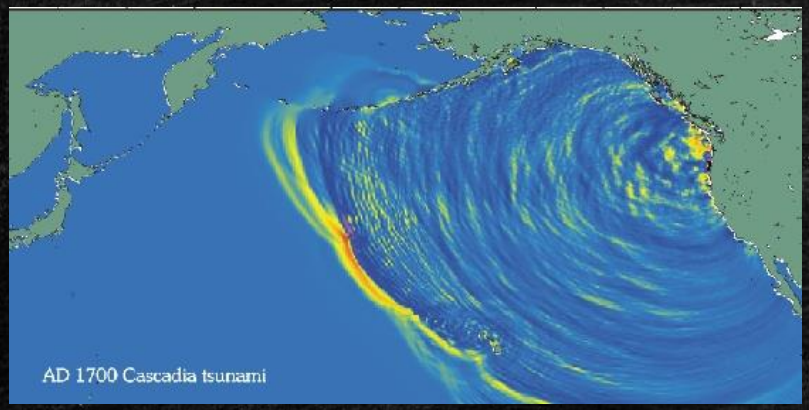
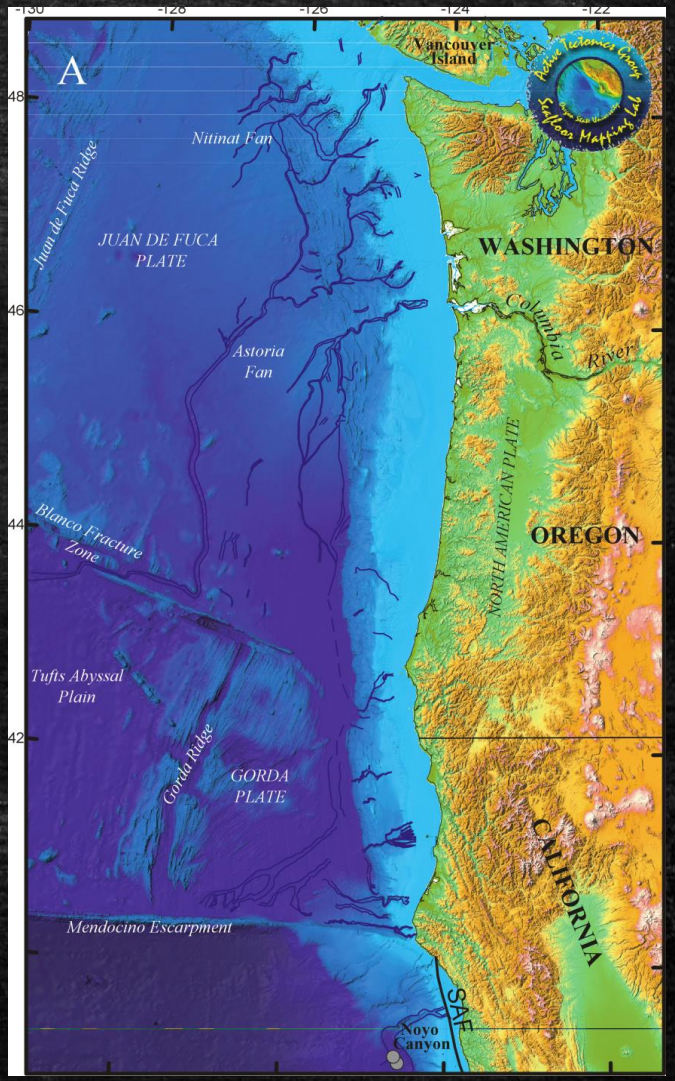



Cascadia submarine canyon systems traverse the locked zone, making them sensitive to ground shaking. They are, for the most part, isolated from river systems during high-stand conditions

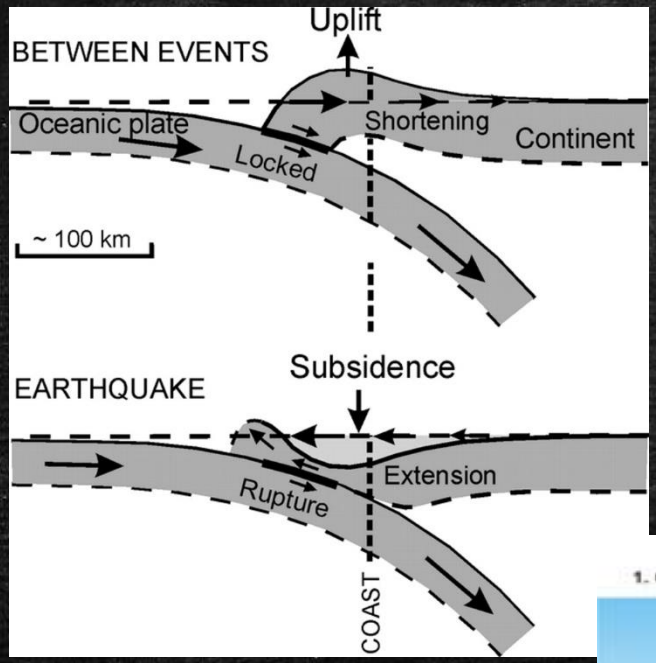
**From Goldfinger et al., 1997 JGR**

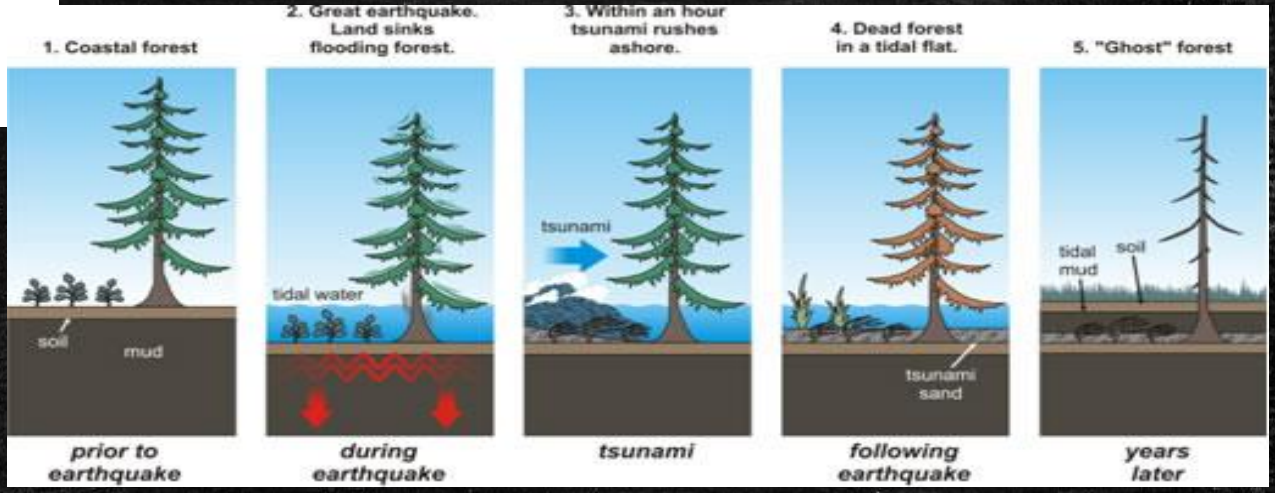
Discovery of the 1700 AD earthquake is a triumph of sleuthing!



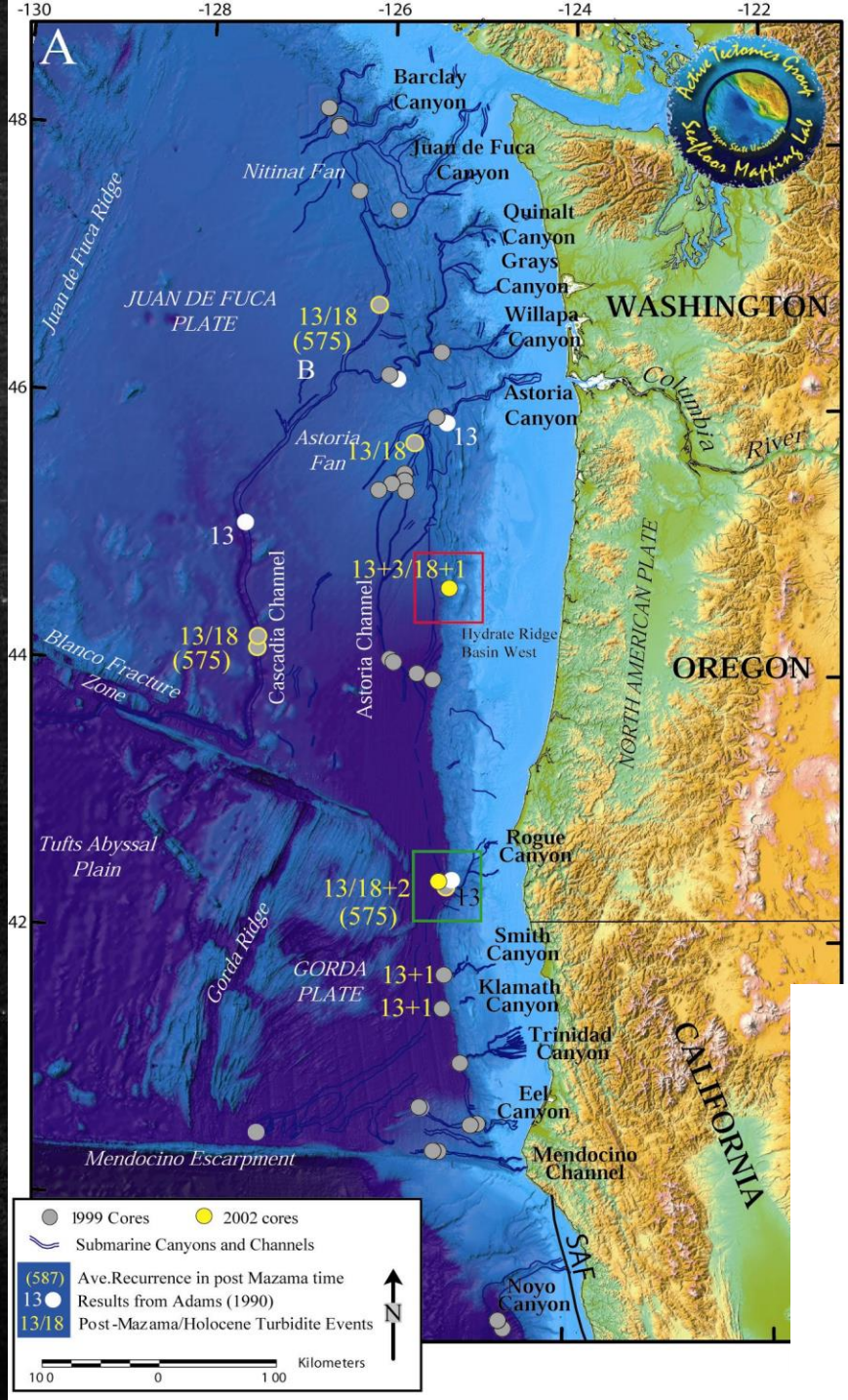
Geologic evidence of great earthquakes is abundant in the form of trees killed by saline incursion, and the peat-bay mud couplets formed by each earthquake.


Uplift
BETWEEN EVENTS
Oceanic plate
Shortening
Continent
Locked
~ 100 km
Subsidence
EARTHQUAKE
Extension
Rupture
COAST


1. Coastal forest
2. Great earthquake. Land sinks flooding forest.
3. Within an hour tsunami rushes ashore.
4. Dead forest in a tidal flat.
5. "Ghost" forest
soil
mud
tidal water
tsunami
tsunami sand
tidal mud
soil
prior to earthquake
during earthquake
tsunami
following earthquake
years later

So our primary criteria for distinguishing earthquakes are

1) Aerial extent
2) Synchroneity, and
3) Sedimentology.




Turbidite Paleoseismology:

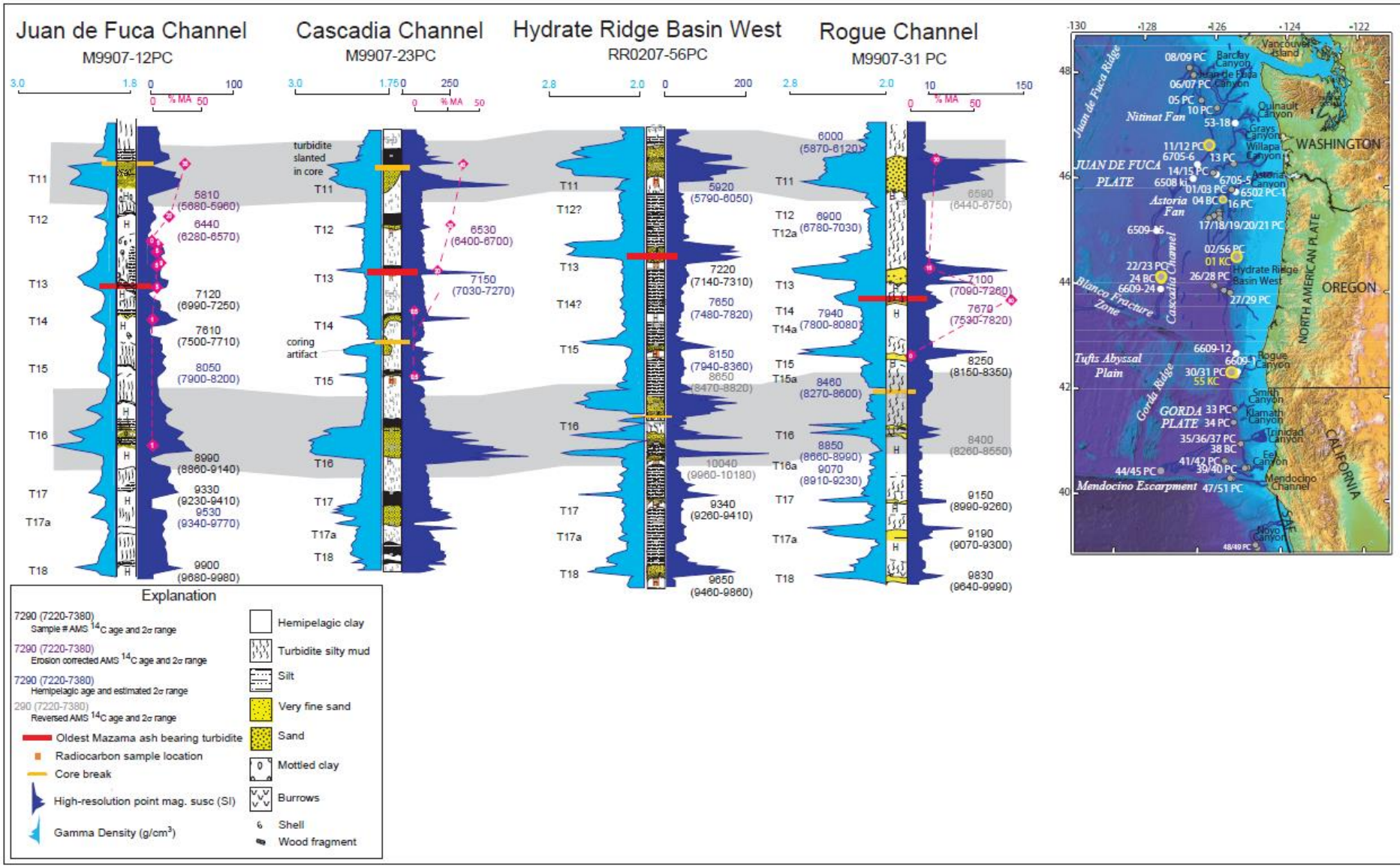
Extending the earthquake record

Cascadia Core Sites:

1999 = gray, 2002 = yellow

Older existing cores = white

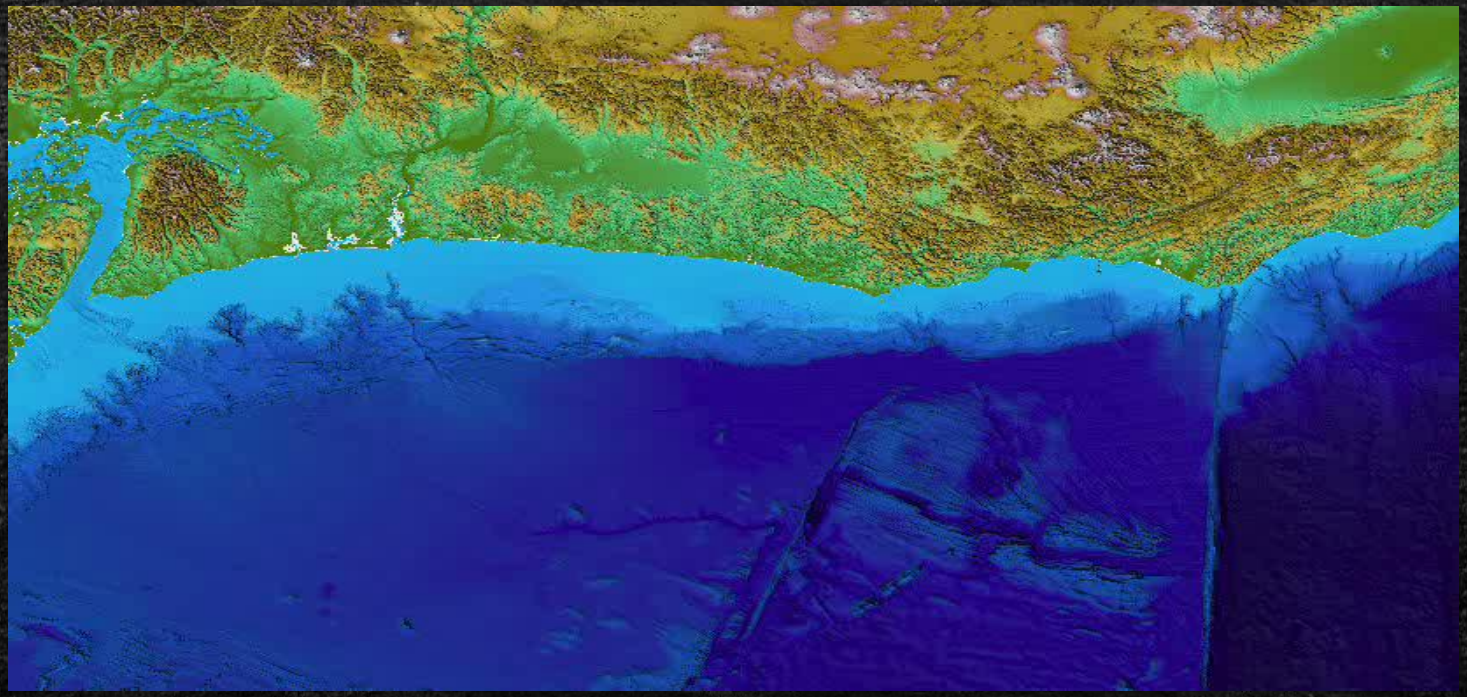
Washington Channels defined by 12 days of multibeam survey, now un-classified!

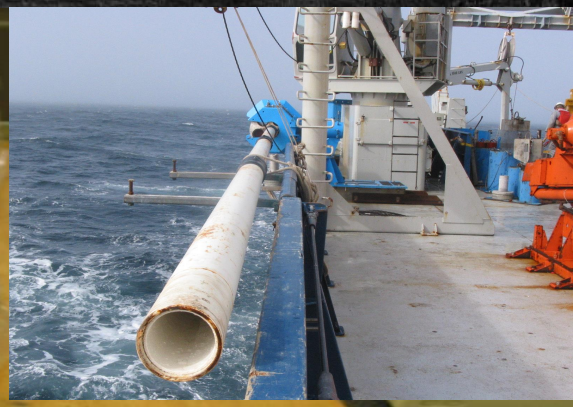

Juan de Fuca Channel
M9907-12PC
Cascadia Channel
M9907-23PC
Hydrate Ridge Basin West
RR0207-56PC
Rogue Channel
M9907-31 PC
% MA
T11
T12
T13
T14
T15
T16
T17
T17a
T18
5810 (5680-5960)
6440 (6280-6570)
7120 (6990-7250)
7610 (7500-7710)
8050 (7900-8200)
8990 (8860-9140)
9330 (9230-9410)
9530 (9340-9770)
9900 (9680-9980)
turbidite slanted in core
coring artifact
6530 (6400-6700)
7150 (7030-7270)
5920 (5790-6050)
7220 (7140-7310)
7650 (7480-7820)
8150 (7940-8360)
8650 (8470-8820)
10040 (9960-10180)
9340 (9260-9410)
9650 (9460-9860)
6000 (5870-6120)
6900 (6780-7030)
7940 (7800-8080)
8460 (8270-8600)
8850 (8660-8990)
9070 (8910-9230)
6590 (6440-6750)
7100 (7090-7260)
7670 (7530-7820)
8250 (8150-8350)
8400 (8260-8550)
9150 (8990-9260)
9190 (9070-9300)
9830 (9640-9990)
Explanation
7290 (7220-7380)
Sample # AMS 14C age and 2σ range
7290 (7220-7380)
Erosion corrected AMS 14C age and 2σ range
7290 (7220-7380)
Hemipelagic age and estimated 2σ range
290 (7220-7380)
Reversed AMS 14C age and 2σ range
Oldest Mazama ash bearing turbidite
Radiocarbon sample location
Core break
High-resolution point mag. susc (SI)
Gamma Density (g/cm3)
Hemipelagic clay
Turbidite silty mud
Silt
Very fine sand
Sand
Mottled clay
Burrows
Shell
Wood fragment


Juan de Fuca Ridge
Nitinat Fan
JUAN DE FUCA PLATE
Astoria Fan
Cascadia Channel
Blanco Fracture Zone
Tufts Abyssal Plain
Gorda Ridge
GORDA PLATE
Mendocino Escarpment
Hydrate Ridge Basin West
Rogue Canyon
Mendocino Channel
WASHINGTON
OREGON
CALIFORNIA
NORTH AMERICAN PLATE
Vancouver Island
Barclay Canyon
Quinault Canyon
Grays Canyon
Willapa Canyon
Astoria Canyon
Smith Canyon
Klamath Canyon
Trinidad Canyon
Eel Canyon
Noyo Canyon
08/09 PC
06/07 PC
05 PC
10 PC
53-18
11/12 PC
6705-6
13 PC
14/15 PC
6508 kj
6705-5
01/03 PC
6502 PC-1
04 BC
16 PC
17/18/19/20/21 PC
6509-35
02/56 PC
01 KC
22/23 PC
24 BC
6609-24
26/28 PC
27/29 PC
6609-12
6609-1
30/31 PC
55 KC
33 PC
34 PC
35/36/37 PC
38 BC
41/42 PC
39/40 PC
44/45 PC
47/51 PC
48/49 PC
130
128
126
124
122
48
46
44
42
40

What actually happens during the earthquake?

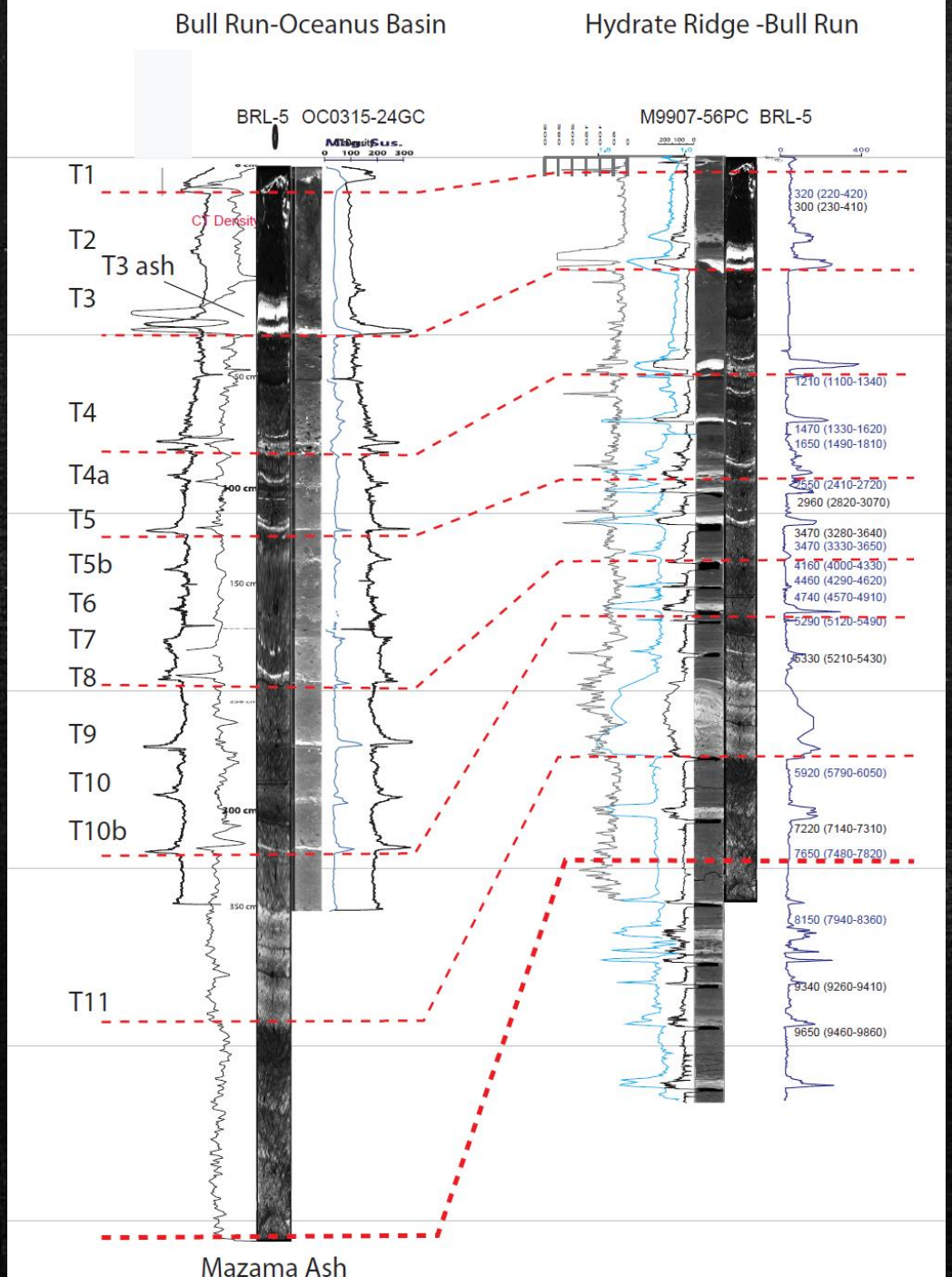
Synchronous turbidity currents are triggered within a few minutes of each other along the length of the margin





Turbidites are easy to capture, but what do they mean?

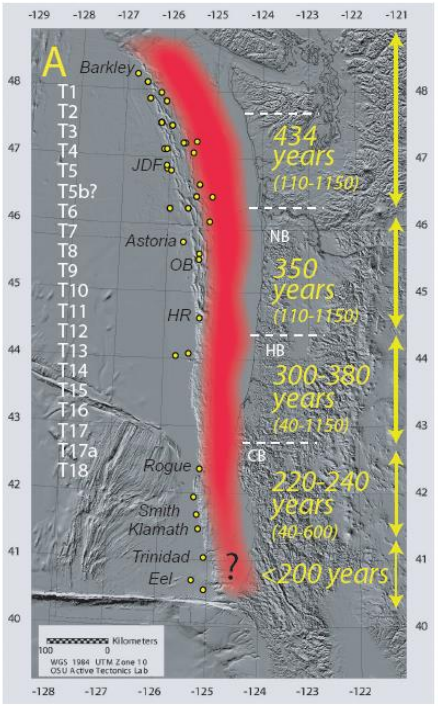

THOMAS G. THOMPSON

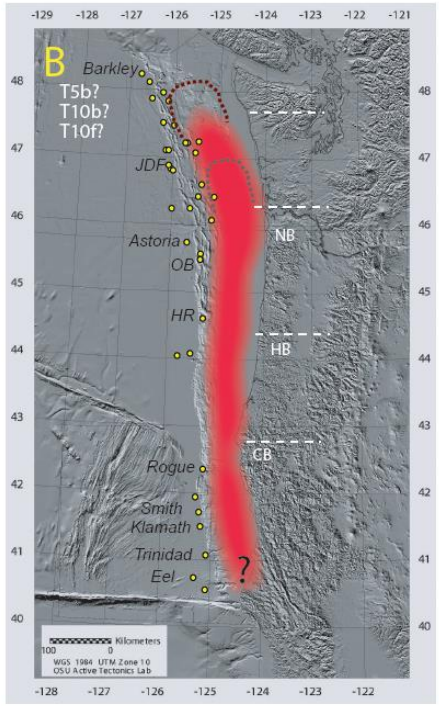


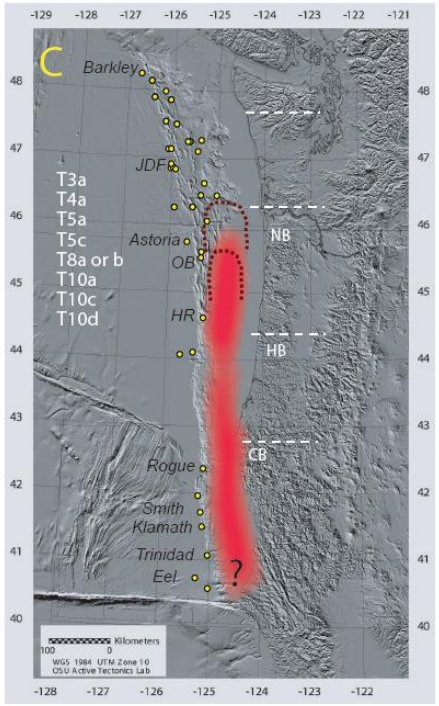

Preliminary correlation: Bull Run-Oceanus basin-Hydrate Ridge.

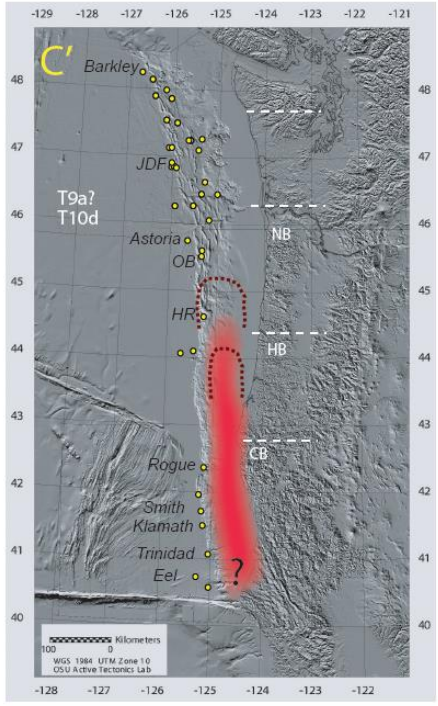
Anchored by the regionally robust T11, the Mazama Ash, and well-log correlation, we infer a good correlation between Bull Run and both offshore sites.

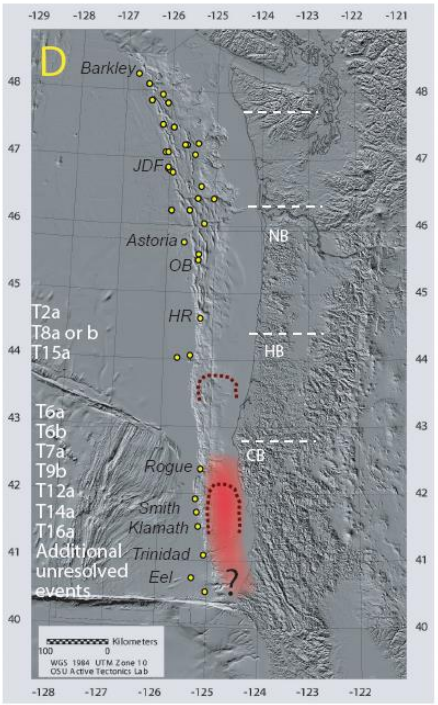
Interestingly, offshore significant event T3 also coincides with an ash in Bull Run Lake, suggestive of a potential connection. Similarly, we noted that regional event T14 is associated with the Mazama ash event temporally, and stratigraphically where airfall occurred.

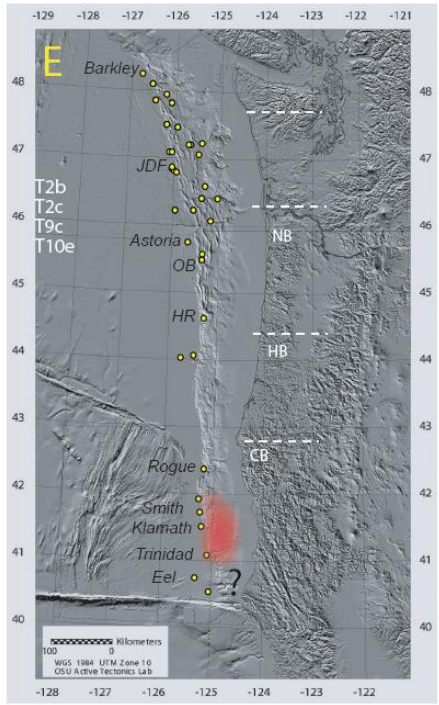


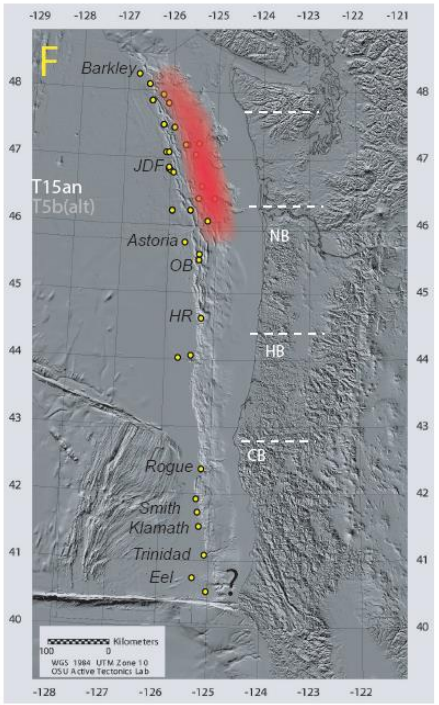



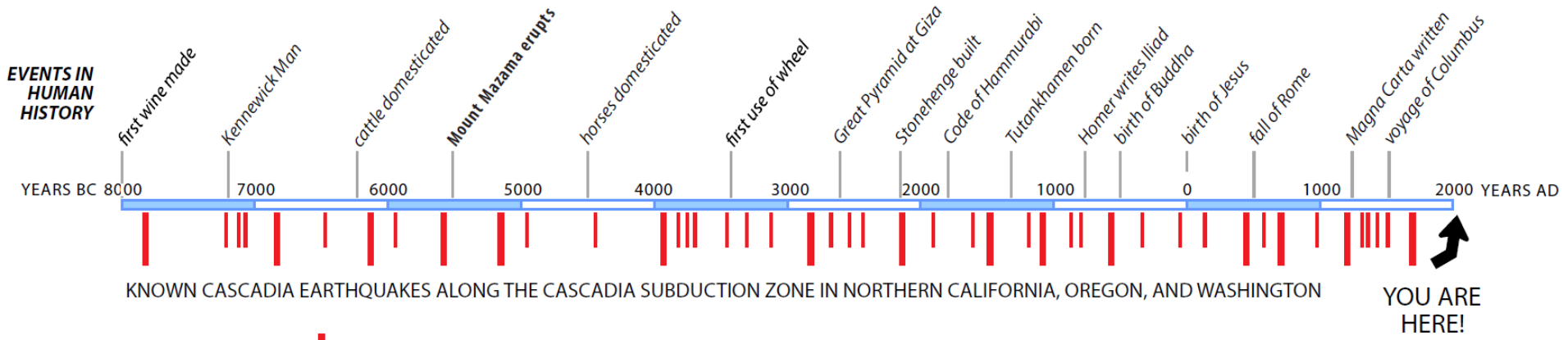




2015 update of segment boundaries, events counts and regional probabilities.

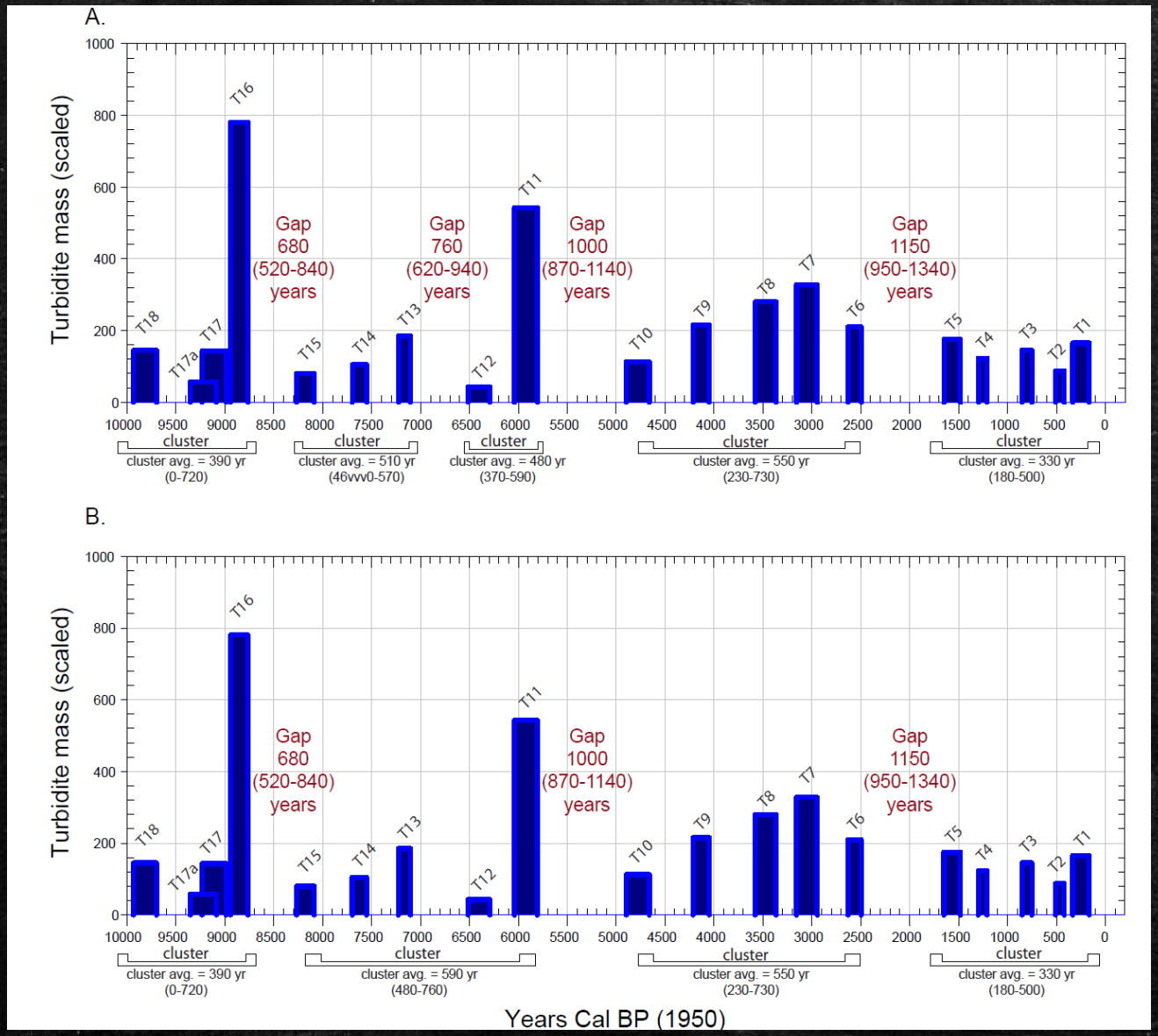
# Cascadia Earthquake Timeline




Earthquake of Magnitude 9+ (fault breaks along entire subduction zone)

Earthquake of Magnitude 8+ (fault breaks along southern half of subduction zone)

# Third Generation Paleoseismology



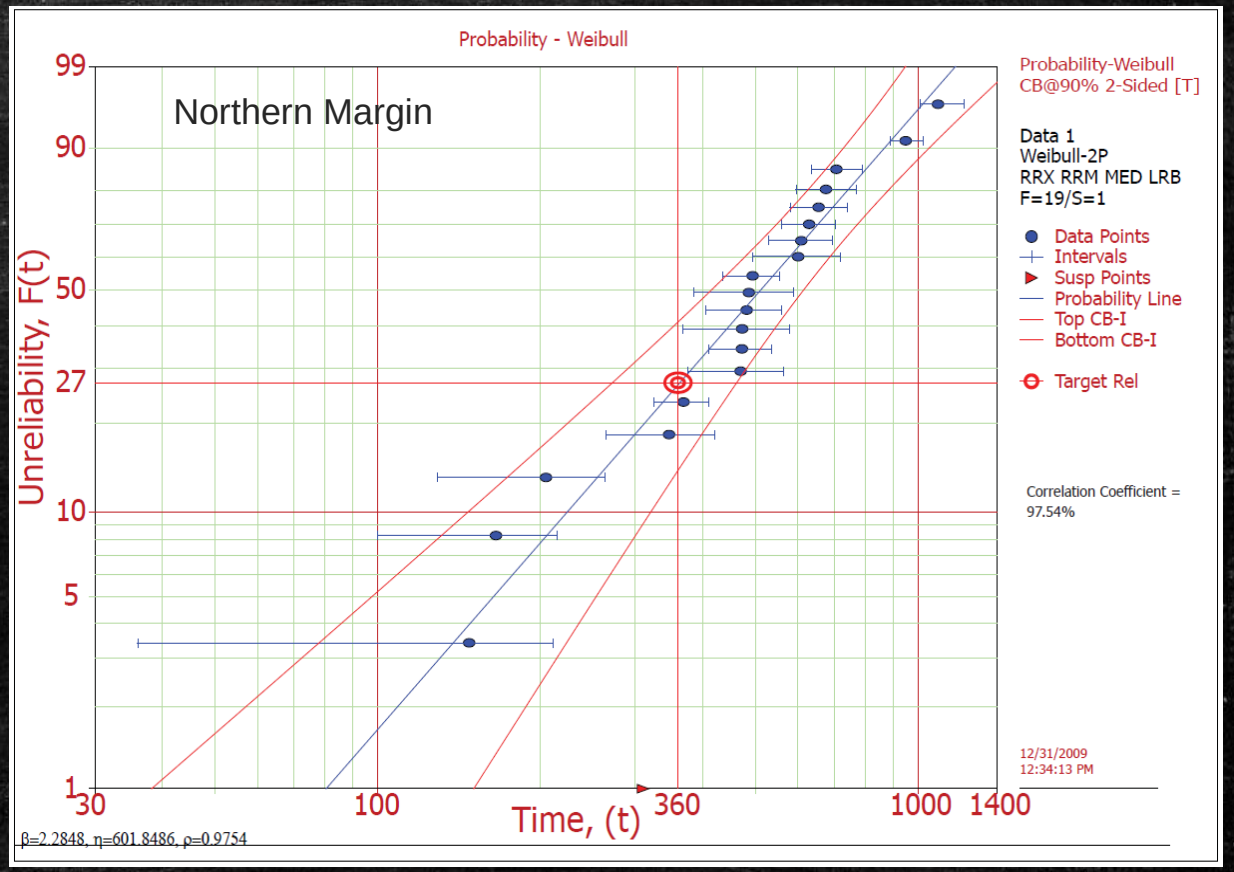

## What about clustering?

There seems to be a poorly developed clustering, suggested here.

It certainly makes a difference whether the next expected event is part of a cluster or not, if clusters exist, and if the next event reflects a repeat of recent behavior. Clustering seems better developed in the latter half of the Holocene. If a repeat were to occur, a gap may be next.

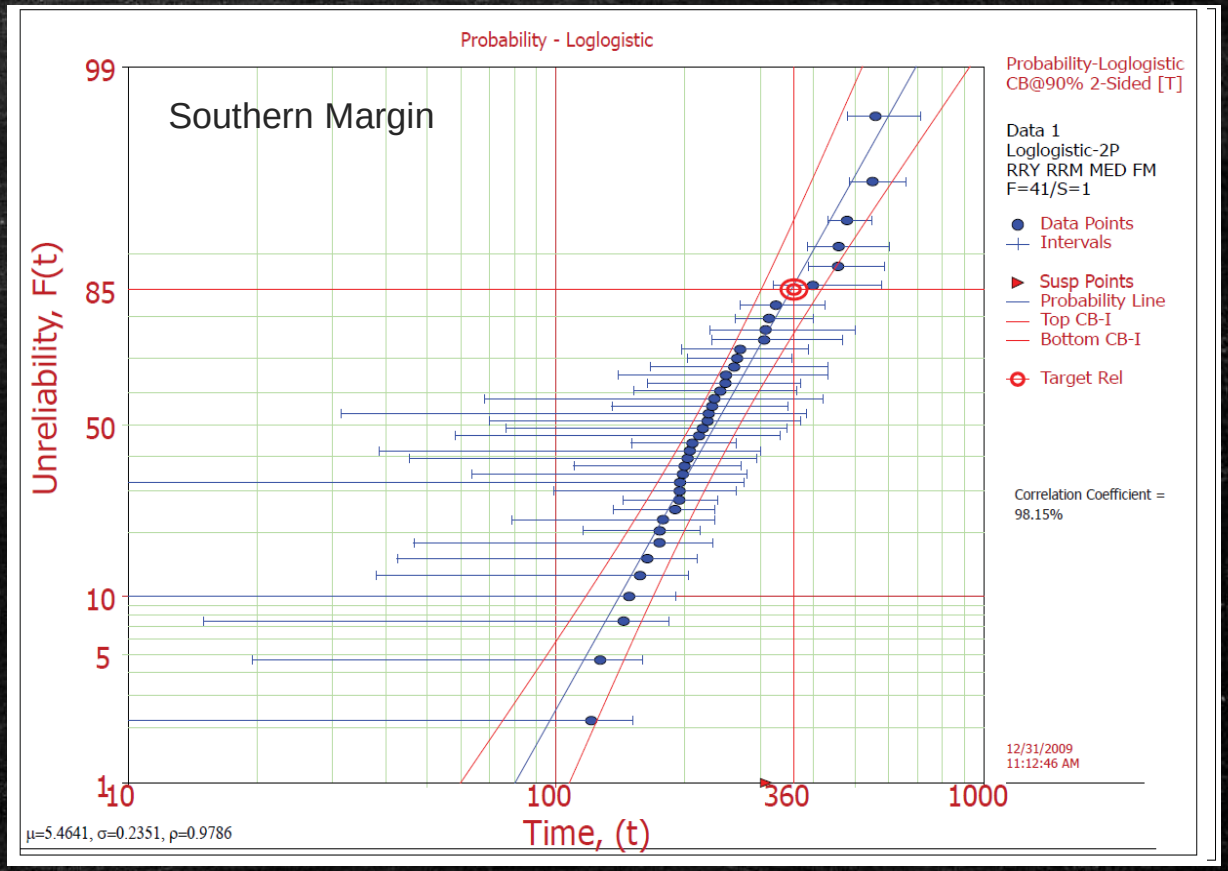
For the northern margin, probabilities are relatively low, many intervals longer than 360 years are in the paleoseismic record.

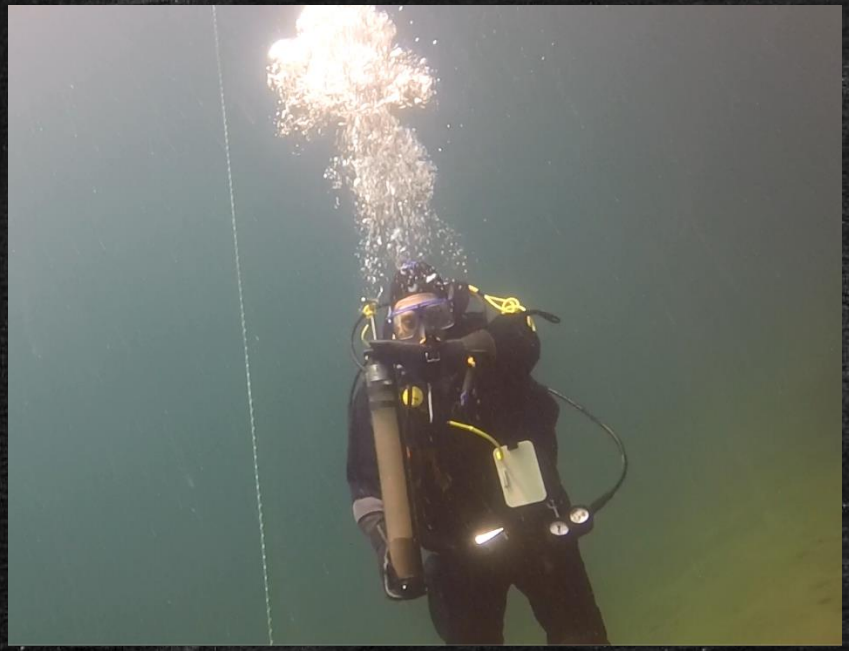
The reliability analysis suggests at 360 years, 25% of repeat times will have been exceeded. Conditional probability in 50 years is 12% (7-15%).

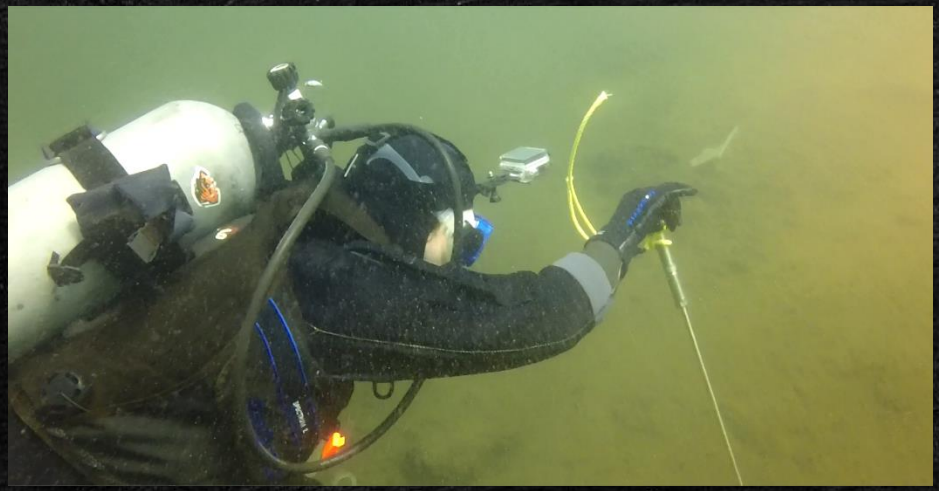


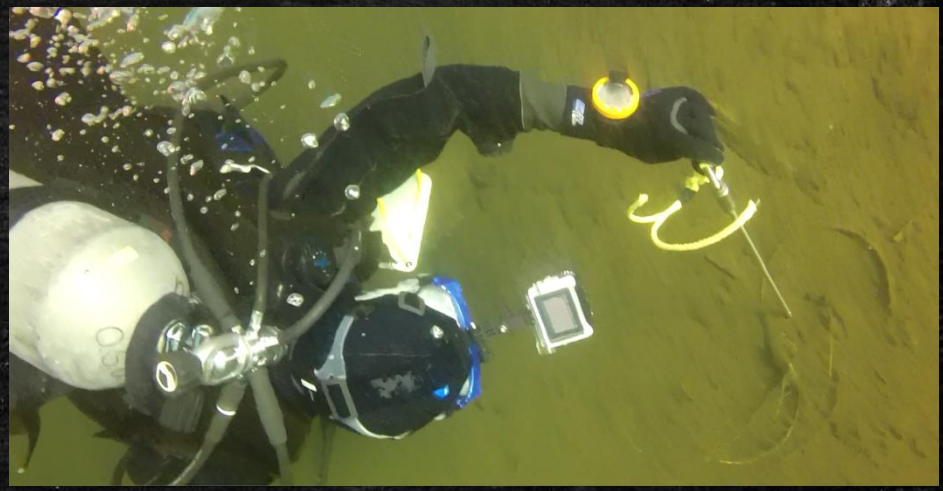
For the southern margin, if our interpretation is correct, 70-93% of repeat times will have been exceeded.

Conditional probability in 50 years is 37% (32-42%).



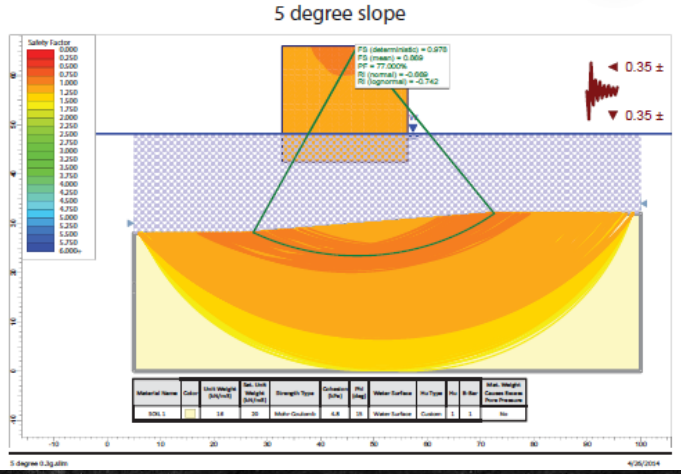






# PGA-PGV sensitivity of sites

*Figure 13.* (right) Factor of safety at a 5 degree slope.



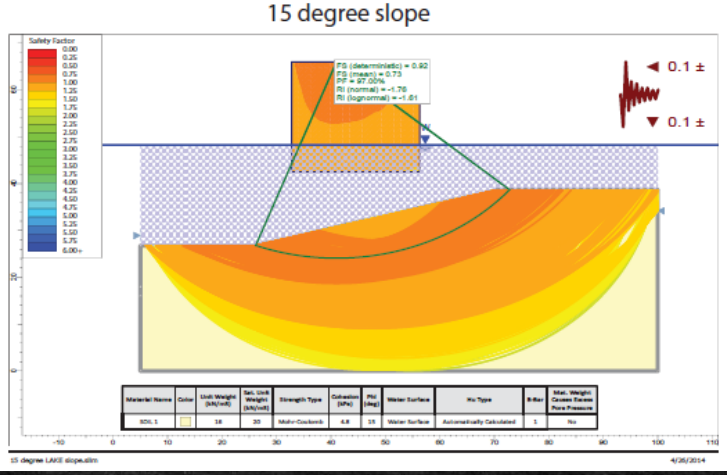
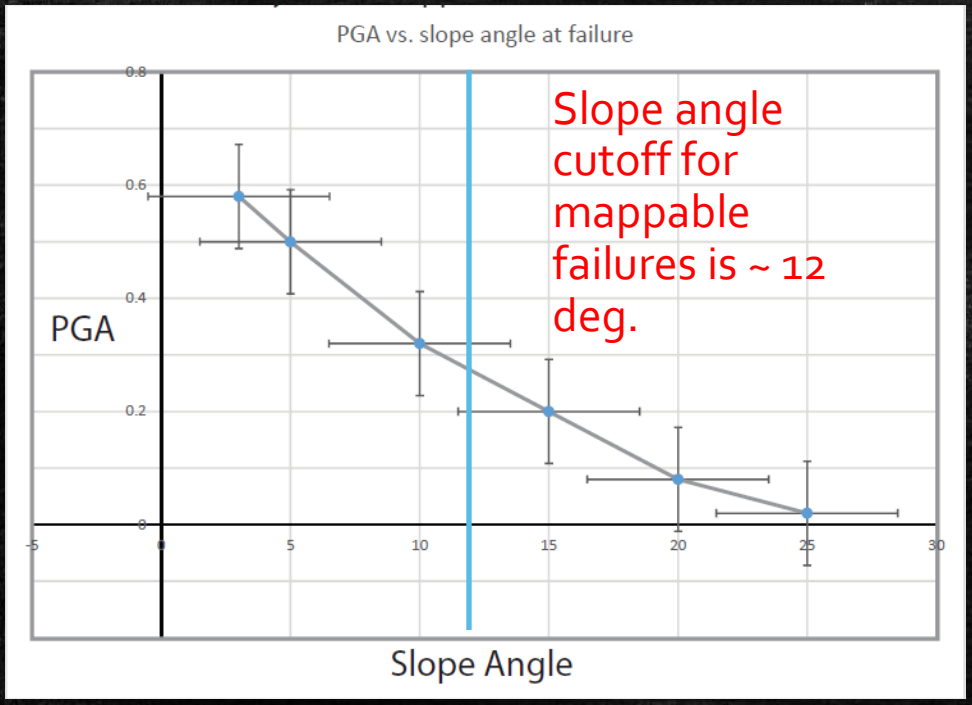




*Figure 14.* (left) Factor of safety at a 15 degree slope.




Slope angle cutoff implies a PGA of ~ 0.3g for the most extreme event recorded in shallow sediments of Bull Run Lake. This may be in reasonably good agreement with the USGS 2014 value of 0.3g for the 2500 year event based on GMPE modeling.


Thanks for your attention!