Cascadia Earthquake Facts:

What You Need To Know

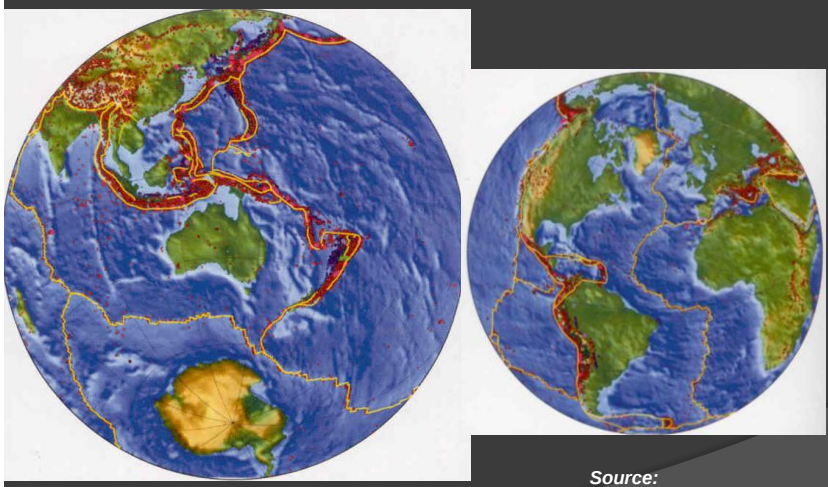
Tsunami Outreach Oregon
Oregon Department of Geology and Mineral Industries

Cascadia Earthquake: Key Messages

- A local Cascadia earthquake will probably happen in most people's lifetime or their children's lifetime.
- A ~Mw 9 earthquake is the maximum Cascadia event, similar to the 2004 Mw 9.0 Sumatra earthquake. ~20 have occurred in the last 10,000 years.
- Smaller Cascadia earthquakes can occur between the maximum events but will be confined to southern Oregon and northern California. Check out the 2010 Mw 8.8 Chile earthquake for damage from these events.
- Moderate shaking at the coast for minutes; low to moderate shaking in the Valley.
- Collapse of unreinforced masonry buildings, shattered windows, "wracked" wood frames.
- Damaged bridges and landslides cut roads.
- Coastal populations will be in isolated "islands" for several days to a few weeks. "**Island planning**" is effective.
- DUCK, COVER AND HOLD!!!
- Family plan and individual self reliance will make the difference.

Introduction – Plate Tectonics

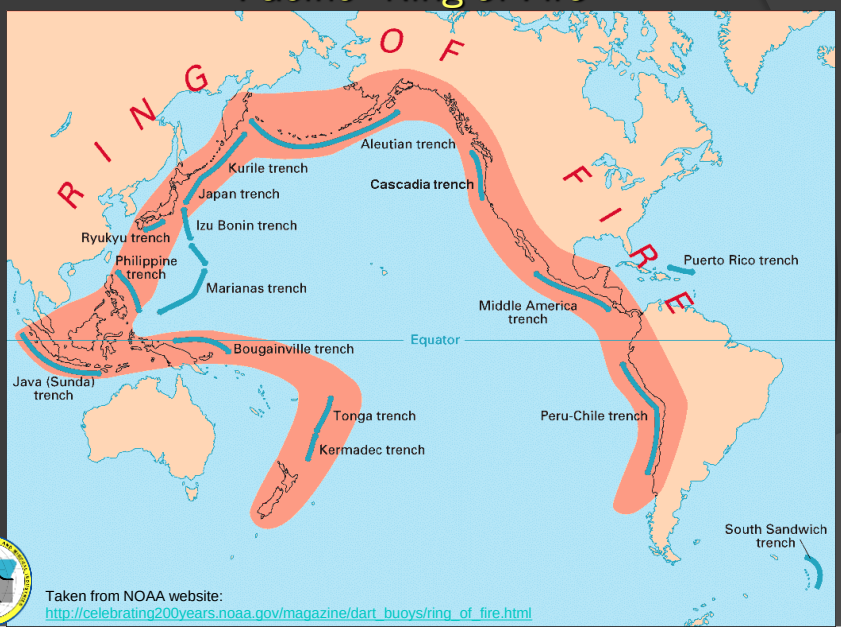
95% of earthquakes occur along the edges of the interacting plates



Source:

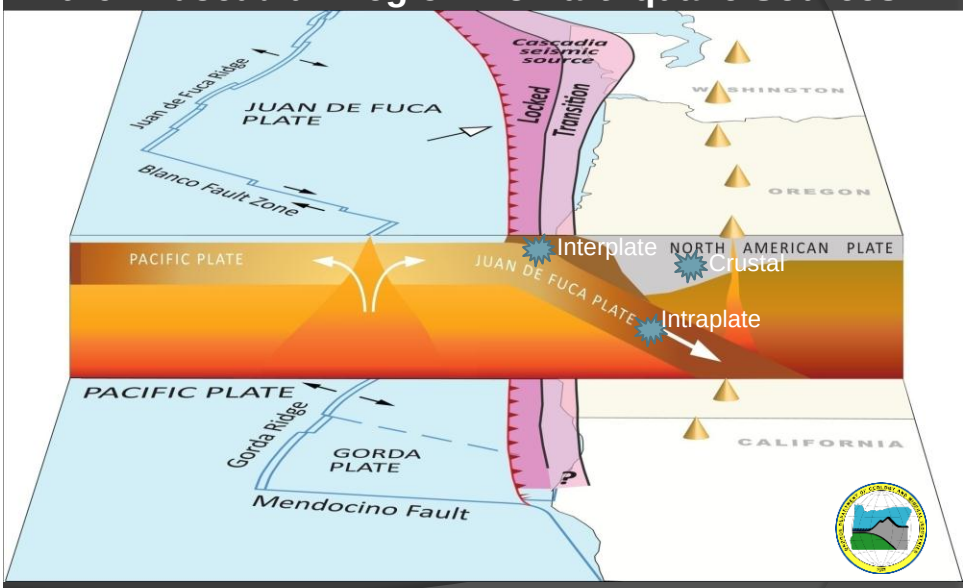
*http://www.google.com/url?sa=t&source=web&ct=res&cd=1&ved=0CBEQFjAA&url=http%3A%2F%2Fwww.eeri.org%2Flfe%2Fclearinghouse%2Fsumatra_tsunami%2Fpresentation%2FTsunami_FINAL_4-19-05_novideo_website.ppt&ei=ZsWaS_HSJ5OysgPe1sWdAg&usg=AFQjCNFkoW2w14KrfRS4lPGW4l5tCSCpjg : from **Earthquakes** by Bruce A. Bolt*

Subduction Zones Earthquake Sources of the Pacific "Ring of Fire"



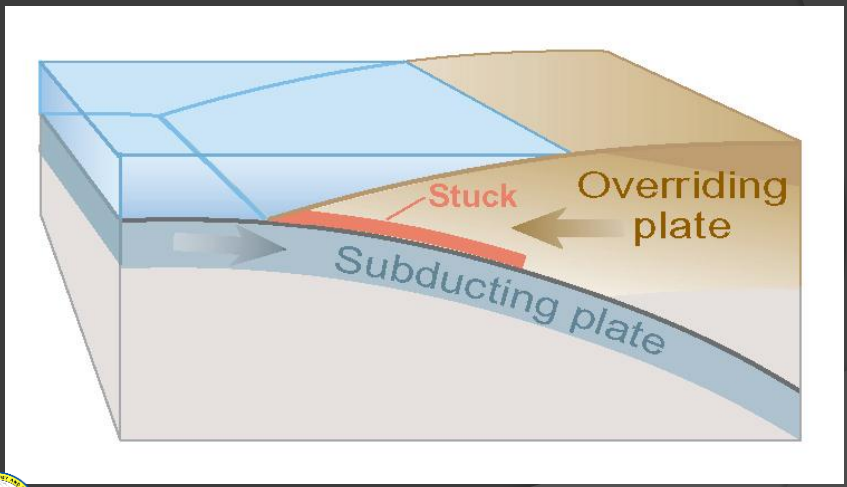
Taken from NOAA website:
http://celebrating200years.noaa.gov/magazine/dart_buoys/ring_of_fire.html

Plate Tectonic Map of the Pacific Northwest – the "Cascadia" Region – 3 Earthquake Sources



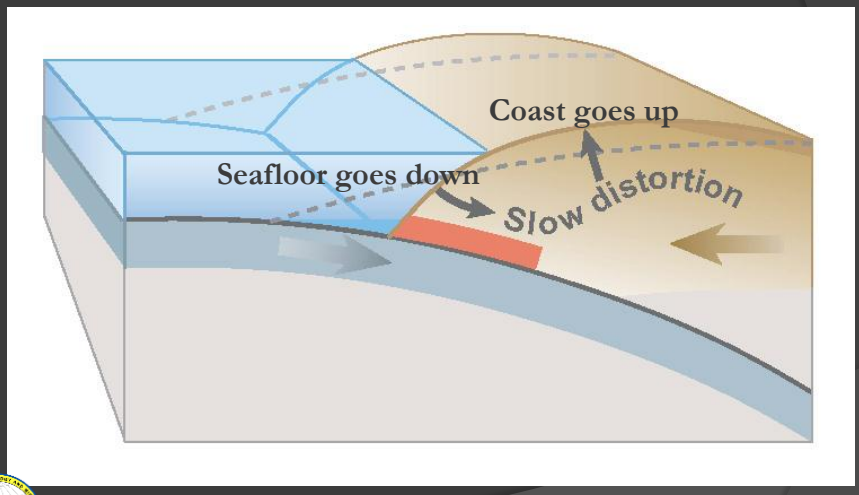
Modified from 2010 issue of ***Cascadia***, Oregon Dept. of Geology and Mineral Industries

Vertical Slice through Subduction Zone



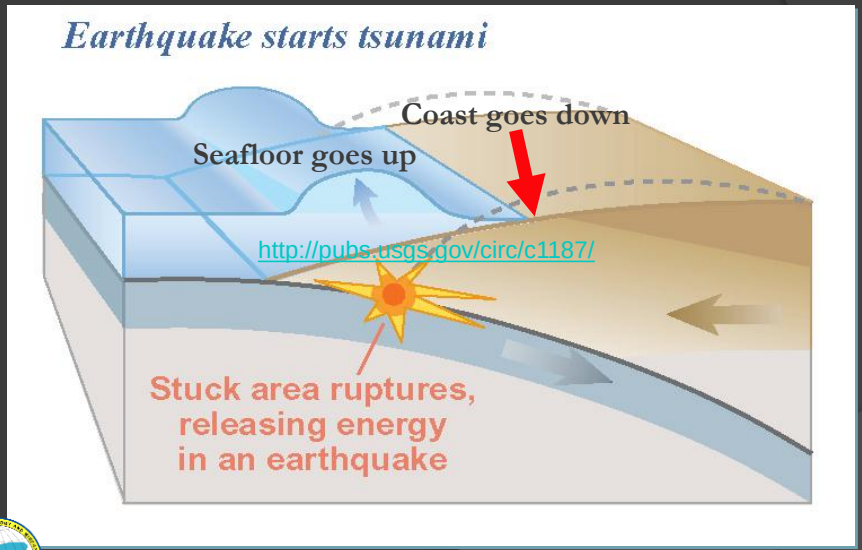
Source: http://pubs.usgs.gov/circ/c1187/

Between Earthquakes



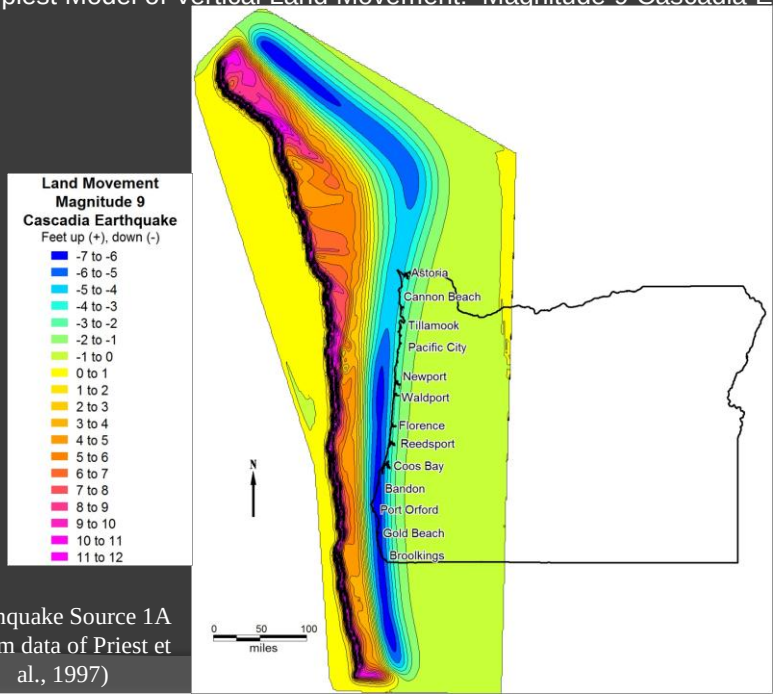
Source: http://pubs.usgs.gov/circ/c1187/

During an Earthquake

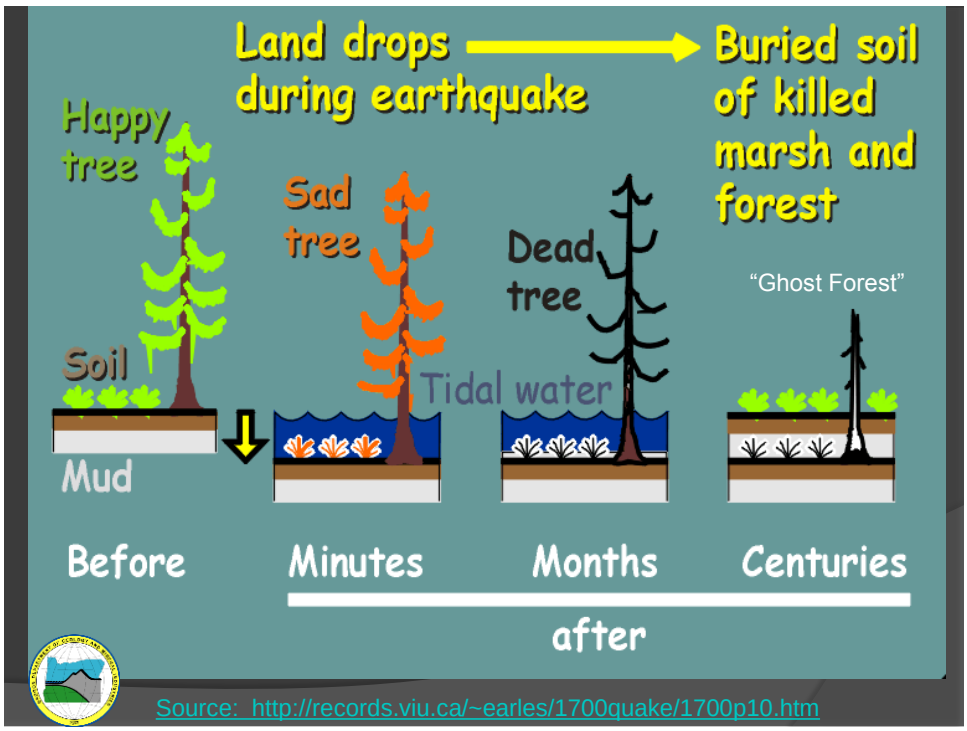


Source: http://pubs.usgs.gov/circ/c1187/

Simplest Model of Vertical Land Movement: Magnitude 9 Cascadia Earthquake



Earthquake Source 1A (from data of Priest et al., 1997)



Source: http://records.viu.ca/~earles/1700quake/1700p10.htm

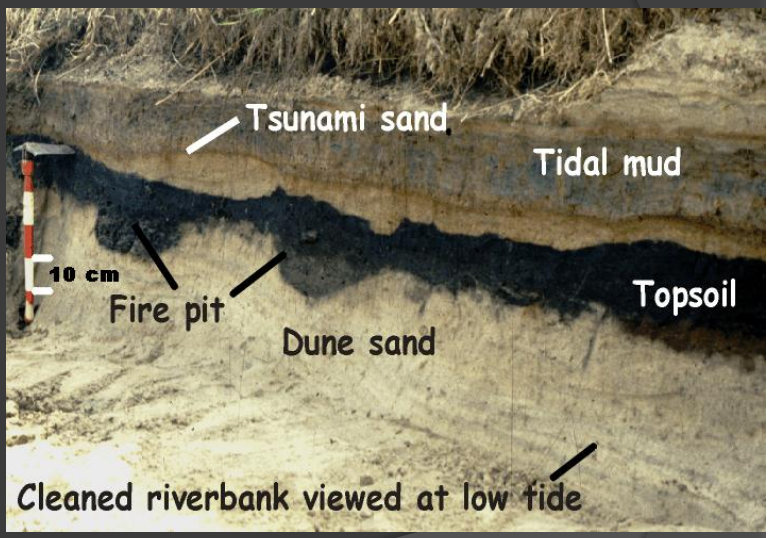
"Ghost Forest" at Copalis River, Washington
(Brian Atwater in picture)

Western red cedar trees killed when the land sank during the AD 1700 Cascadia earthquake. These trees were brought down to the intertidal zone where salt water killed them.

Source: http://records.viu.ca/~earles/1700quake/1700p11.htm

Buried soil and fire pits capped by AD 1700 tsunami sand
Salmon River, Oregon (Lincoln City area)

Soil from forest (black topsoil) occupied by native Americans (fire pits) was struck by a tsunami (tsunami sand) and brought down to intertidal level (tidal mud) by the AD 1700 Cascadia subduction zone earthquake.



Source: http://records.viu.ca/~earles/1700quake/1700p12.htm

Turbidites:
Adams (1990) finds "footprints" offshore

SHAKING LEAVES A DEEP-SEA DEPOSIT

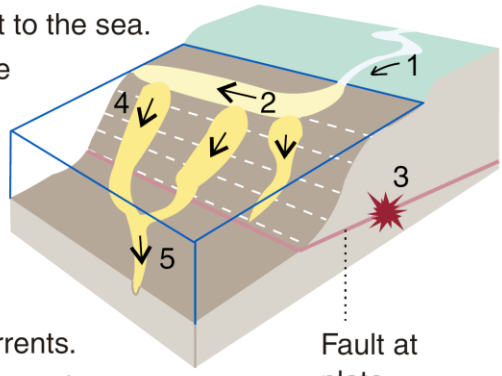
1 **River** delivers sediment to the sea.

2 **Sediment** settles on the continental shelf.

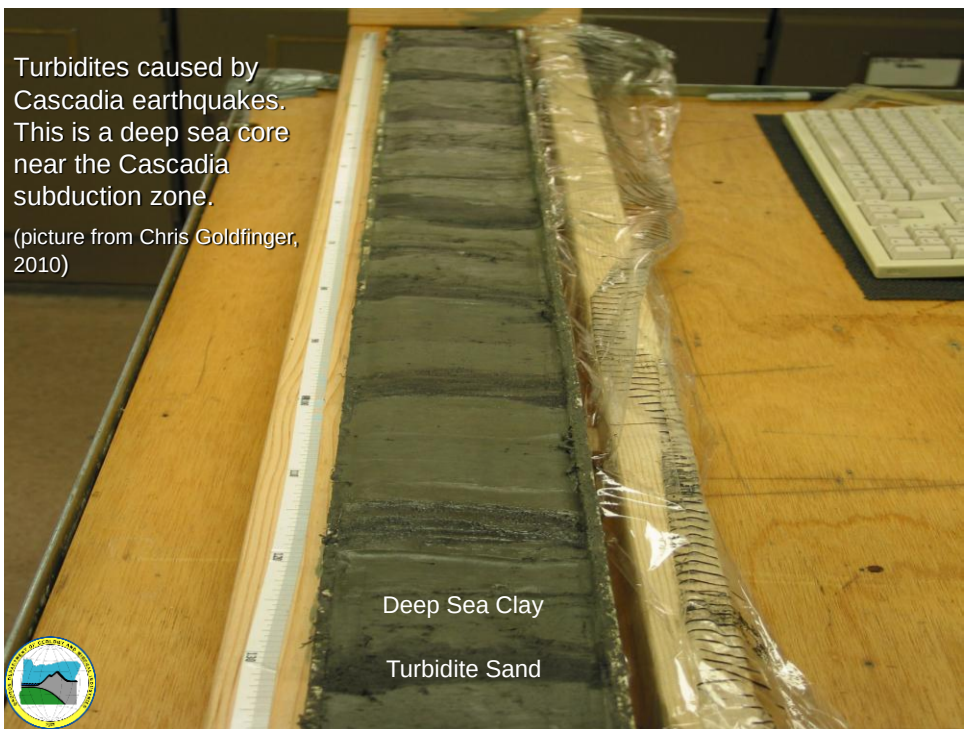
3 **An earthquake** shakes the continental shelf and slope.

4 **Shaken sediment** descends submarine canyons as turbidity currents.

5 **Turbidity currents** merge where tributaries meet. Resulting deposits are visible in sediment cores.

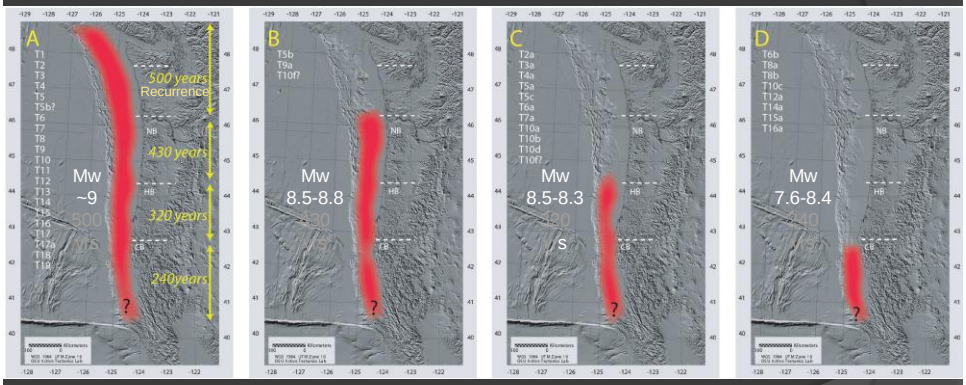


Source: Atwater (2005); http://pubs.usgs.gov/pp/pp1707/



Cascadia Subduction Zone Earthquakes

Turbidites show how much of the subduction zone ruptured in ~42 earthquakes over the last 10,000 years.

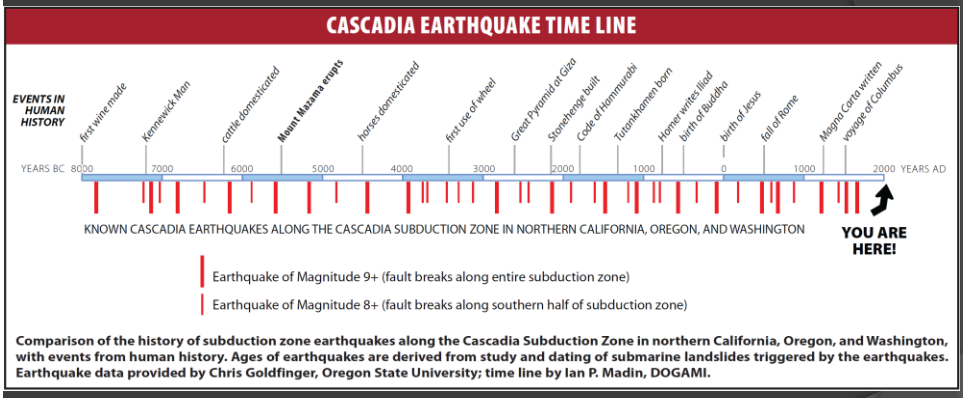


(Modified from Goldfinger et al. (in press) by adding magnitude estimates and some labels)

- 20 earthquakes ruptured all of the subduction zone.
- 2 to 3 earthquakes ruptured three quarters of subduction zone.
- 19 earthquakes ruptured the southern half or quarter of the subduction zone.

Implications of the Turbidite Data

- 19-20 giant (Mw 9+) earthquakes struck the whole Cascadia margin in the past 10,000 years. USGS estimates a ~10 to 14% chance in the next 50 years for these earthquakes (Peterson et al., 2002, *Pure and Applied Geophysics*, v. 159, p. 2147-2178).
- Smaller (~Mw 7.6 to 8.5) Cascadia earthquakes occur between the Mw 9+ earthquakes in southernmost part of the subduction zone. These events will probably be felt throughout the Oregon coast.
- Counting both the smaller and giant Cascadia earthquakes, 40-42 struck in southernmost Oregon (south of Bandon) in the last 10,000 years.
- There is a strong possibility that the next Cascadia earthquake will happen during your or your children's lifetime.



Source: 2010 issue of ***Cascadia***

A Note About Probabilities

Risk:

•Probability of Event x Potential Loss

Outcome:	30-year Probability of Occurrence
Being In A Car Accident	59.9%
50-year old Oregon Male Will Die	40.3%
50-year old Oregon Female Will Die	27.1%
At Least One 100-year Flood	26.0%
30-year old Oregon Male Will Die	10.8%
Magnitude 8-9 Cascadia Subduction Earthquake & Tsunami	10.0%*
Your Vehicle Stolen	9.5%
30-year old Oregon Female Will Die	6.4%
You Are Robbed	3.0%
Have Residential Fire	1.2%
Killed In Car Accident	0.9%

* USGS Press Release April 14, 2008

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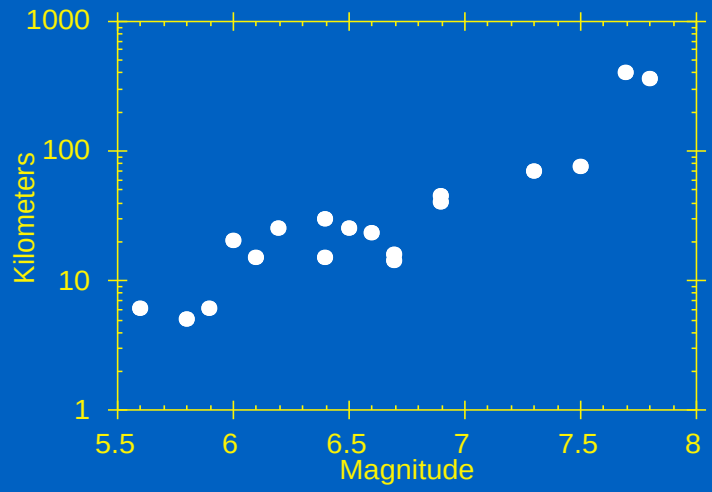
Bigger Faults Make Bigger Earthquakes

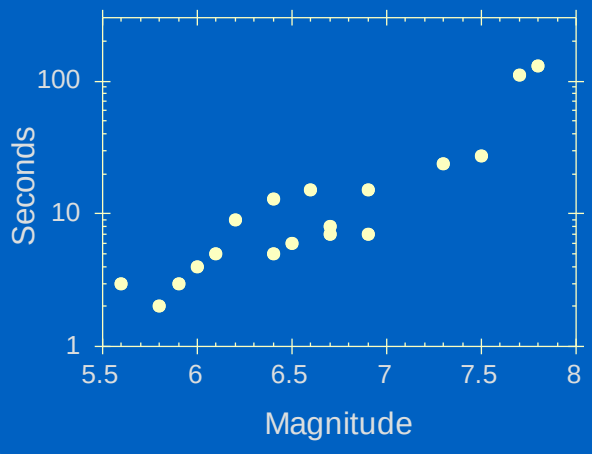


USGS

Note that vertical axis is fault length.

Source: http://earthquake.usgs.gov/learn/topics/?topicID=57

Bigger Earthquakes Last a Longer Time



USGS

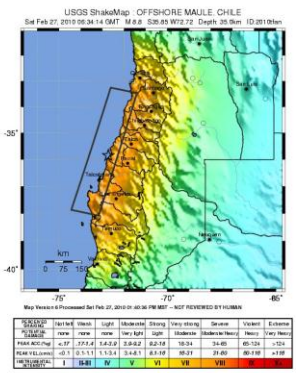
Source: http://earthquake.usgs.gov/learn/topics/?topicID=57

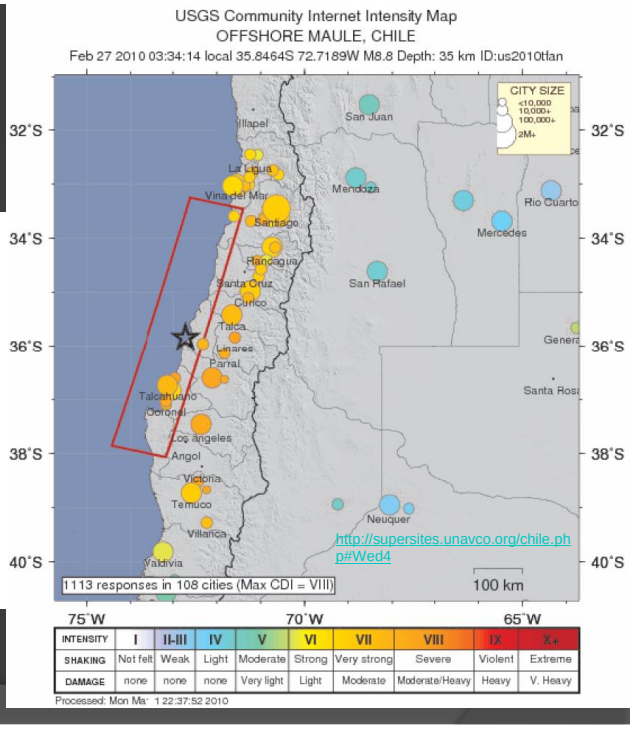
What Controls the Level of Shaking?

- **Magnitude**
  - More energy released
- **Distance**
  - Shaking gets weaker with distance away from the earthquake
- **Local soils**
  - amplify the shaking

USGS Source: http://earthquake.usgs.gov/learn/topics/?topicID=57

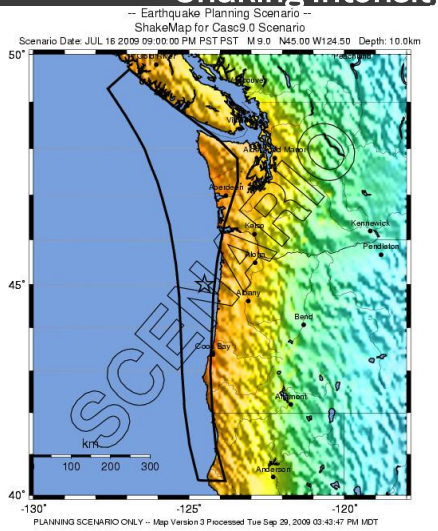
Mw 8.8
2010 Chile Earthquake
Eye Witness Intensity
vs
Instrumental Intensity



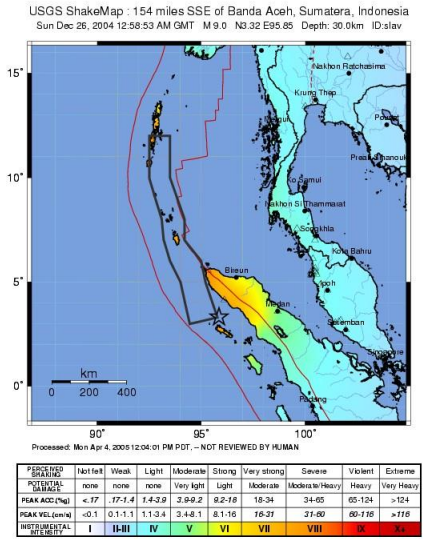


Source:
http://earthquake.usgs.gov/earthquakes/eqarchives/poster/2010/20100227.php

Cascadia versus 2004 Sumatra Earthquake Shaking Intensity for Magnitude 9.0



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+



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Sources:
http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/Casc9.0_se/%3e%20%3chttp://earthquake.usgs.gov/eqcenter/shakemap/global/shake/Casc9.0_se/#1.0_sec_Period

Cascadia ShakeMap Prediction for the Coast

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X

VI. **Strong** – Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.

VII. **Very strong** – Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.

VIII. **Severe** – Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.

IX. **Violent** – Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.

X. **Extreme** – Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

Example: Lincoln City, Oregon (DOGAMI GMS-93)

Soft soils, and steep slopes can AMPLIFY SHAKING

Explanation of Map:
Red Zones = 25% amplification
Black Lines = shorelines

Earthquake Effects - Ground Shaking

Amplification by bay mud in San Francisco causes collapse of the Cypress Freeway.

Loma Prieta, CA 1989

USGS

KGO-TV News ABC-7

Source: http://earthquake.usgs.gov/learn/topics/?topicID=57

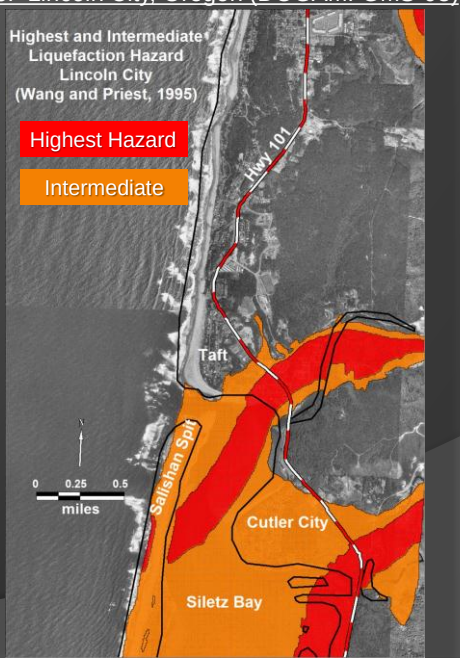
Example: Lincoln City, Oregon (DOGAMI GMS-93)

ShakeMaps do not take into account **LIQUEFACTION** (water-saturated sand or silt turning to quicksand or "quicksilt" during shaking).

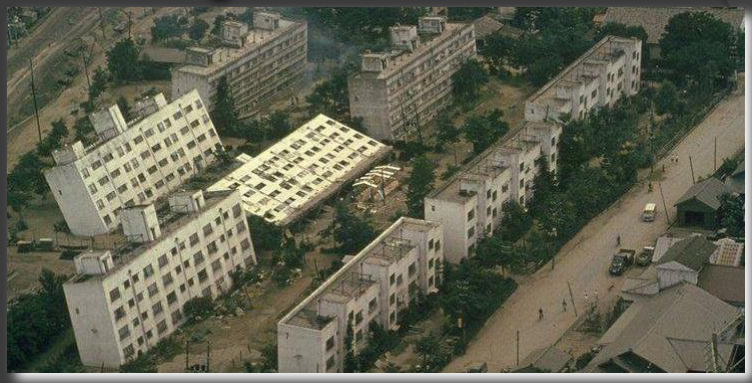
Liquefaction can cause lateral spreading on even gentle slopes.

Heavy objects sink (concrete structures).

Light objects rise (fuel tanks).



Liquefaction



Earthquake shaking can cause soils to behave like a liquid and lose their ability to support structures.

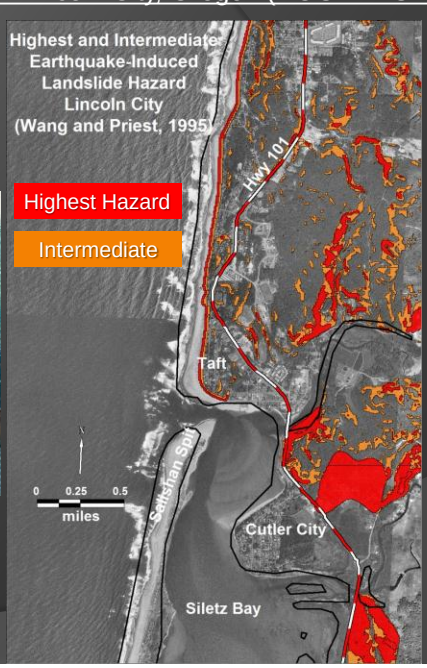
1964 magnitude 7.5 Niigata earthquake in Japan

Example: Lincoln City, Oregon (DOGAMI GMS-93)

ShakeMaps do not reflect damage from **LANDSLIDES** caused by earthquake shaking.

Santa Cruz Mountains, California , 1989

Source: http://earthquake.usgs.gov/learn/topics/?topicID=57



Cape Cove Landslide, December 1999 (rainfall event)

Closed Highway 101 for 3 weeks and caused major economic losses to Yachats

What would happen in a Cascadia earthquake when many more slides occur?

Picture from the Oregon Department of Transportation

Coastal residents and communities must be
<u>self sufficient for days or weeks</u>
after landslides cut the highway system.

Cape Foulweather Landslide December 16, 1999 (rainfall event) cuts Highway 101

Picture from the Oregon Department of Transportation

Earthquake Effects - Fires

Loma Prieta, CA 1989
KGO-TV News ABC-7

USGS

Source: http://earthquake.usgs.gov/learn/topics/?topicID=57

Mitigation and Response

- If you feel an earthquake:
  - Drop, cover and hold
- Earthquake will seriously delay emergency response.
  - Strong ground motions for 3 to 5 minutes.
  - Liquefaction and earthquake force will cause extensive landslides, cutting lifelines
  - Most bridges will be damaged and damage may not be obvious to a lay observer
  - Nearly all buildings will be damaged by the earthquake, including those that may be designated as emergency shelters.
  - Engineer-volunteers should be pre-deputized by local government to designate which structures can be used after the earthquake.
  - Coast will be cut up into **"islands"** by slides and bridge failure, probably for weeks. KNOW THE RESOURCES IN YOUR ISLAND AND PLAN ACCORDINGLY