

Earthquakes in the Pacific Northwest: The Big One and the Other Ones

Harold Tobin

Pacific Northwest Seismic Network

&

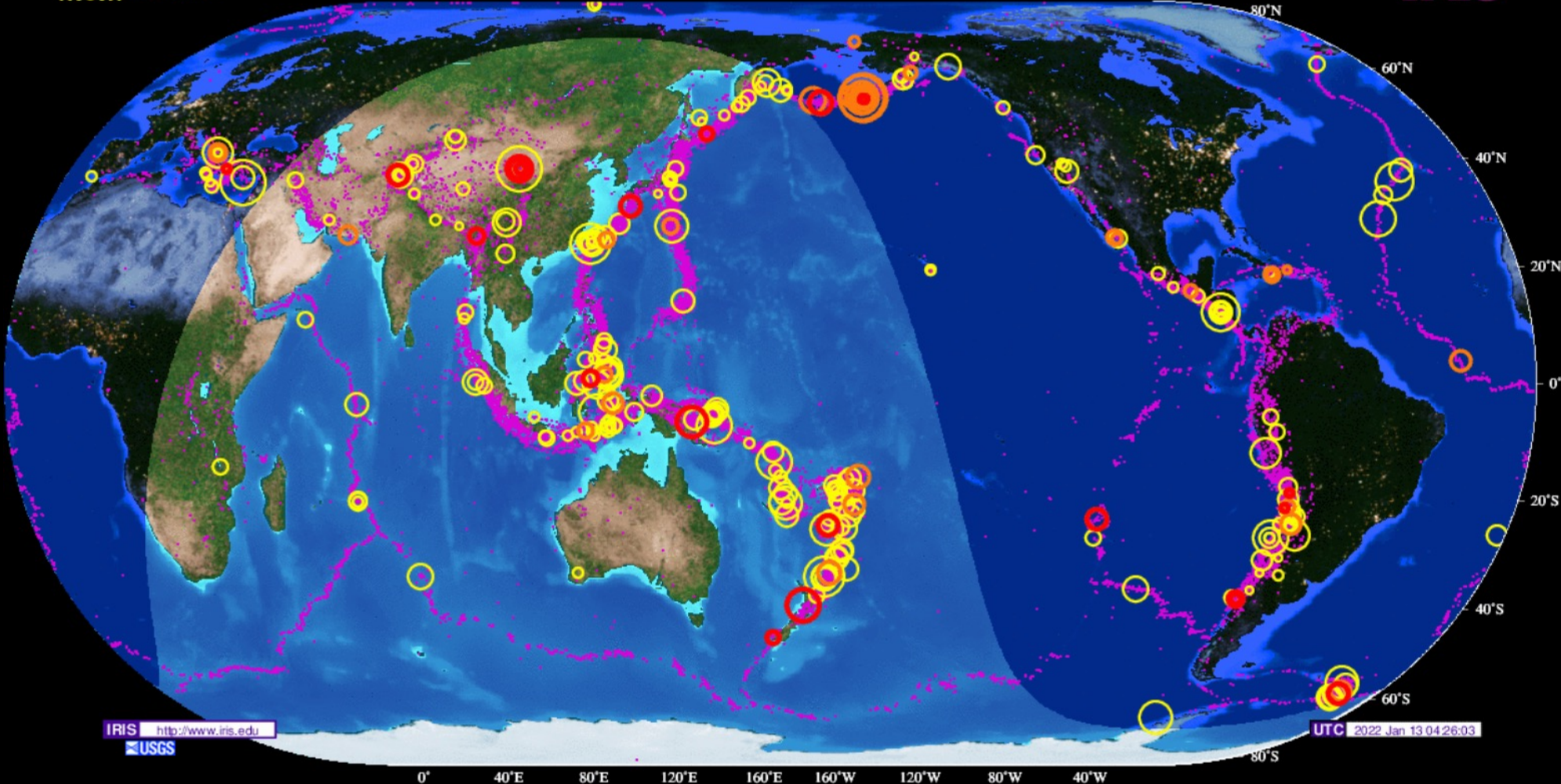
Earth and Space Sciences Department

University of Washington



Thatcher Kelley photo

Earthquakes of the past 2 weeks

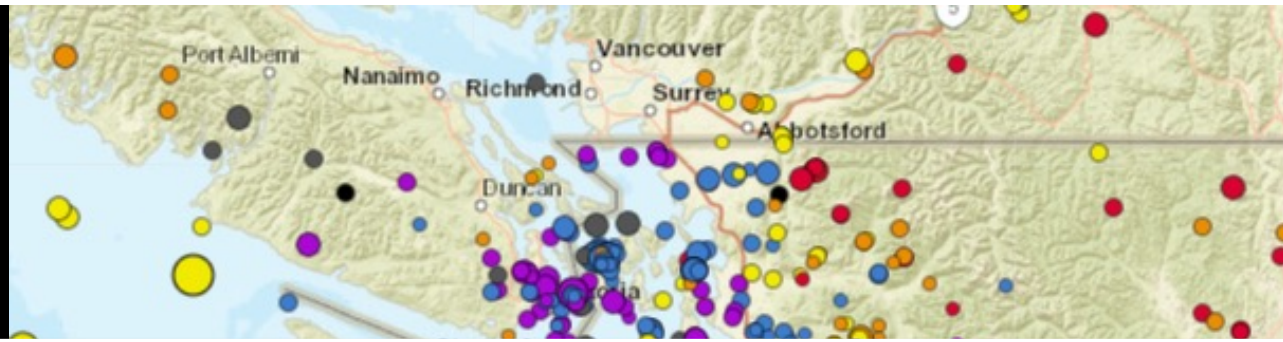


IRIS <http://www.iris.edu>
USGS

UTC 2022 Jan 13 04:26:03

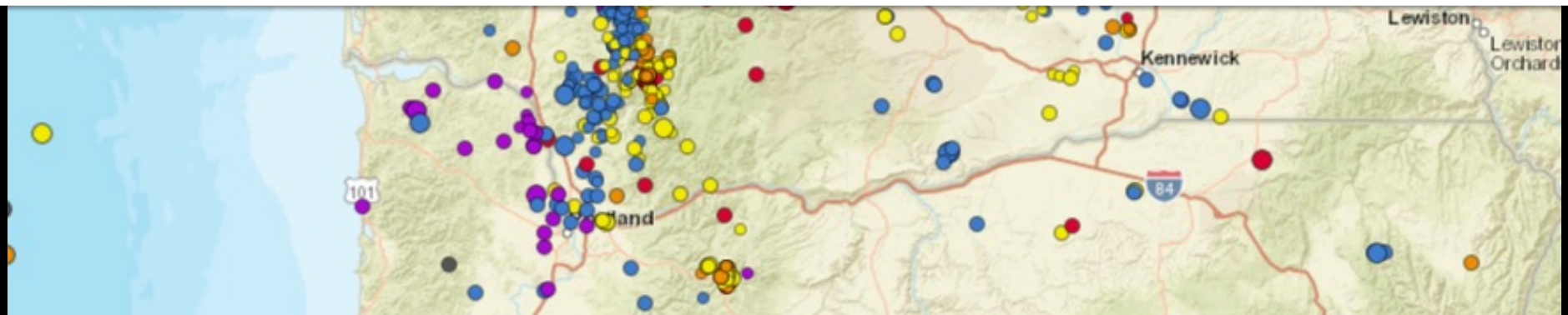
Page served at: Thu Jan 13 4:36:10 GMT 2022

magnitude 4 and above



All earthquakes
magnitude 1.0 or larger
detected by our
seismometer network in
2020

What was the most damaging
(costliest) earthquake in the USA
in the past 25 years?



3 Full Pages Quake Pictures Inside

THE WEATHER
WESTERN WASHINGTON—Sunshine, 6th houring, with some drizzle and partial clearing by afternoon. High, in 80's; low, 36-45. Coastal area tonight 33-38 each.
EASTERN WASHINGTON—Partly cloudy with increasing clouds later. Continental divide with 40% chance of rain above tonight. High, 58-70; low, near 40.

Seattle Post-Intelligencer SUNRISE EDITION
THE QUALITY NEWSPAPER OF THE GREAT NORTHWEST

102nd Year—No. 241 10c SEATTLE, FRIDAY, APRIL 30, 1965 5 52 PAGES MA. 2-2000

Quake Damage In Millions

Five Dead, Many Hurt In Quake

1965

Two Full Pages Quake Pictures Quake News and Pictures On Nine Additional Pages

EXTRA **Seattle Post-Intelligencer** SUNRISE EDITION
Post-Intelligencer Telephone, MAIn 2000 Main Office—6th Ave. and Wal St.

VOL. CXXXVI, No. 44 SEATTLE, THURSDAY, APRIL 14, 1949 40 PAGES 5c PER COPY

SEVEN DEAD, 59 INJURED: EARTHQUAKE LOSS HEAVY

Temblor Lasts Two Minutes; Olympia Area Is Evacuated
Military Police Patrol Downtown Seattle
By Lloyd Stackhouse
Seven persons were killed and at least 59 were injured seriously in an earthquake that

1949

The Pacific Northwest is earthquake country

More people and infrastructure are at risk than in the past

The Olympian GOOD MORNING! HIGH 51 LOW 35 FORECAST, D.D. 50c

THURSDAY, MARCH 1, 2001 SERVING WASHINGTON'S SOUTH PUGET SOUND www.theolympian.com

Epicer 11 miles northeast of Olympia More than two dozen buildings damaged Dozens of injuries; no South Sound deaths

6.8 QUAKE

WHAT YOU NEED TO KNOW NOW

BRIDGE DAMAGE
The Fourth Avenue bridge has been closed indefinitely because of water logging.

BUILDING DAMAGE
19 Capital Complex has been severely damaged and some other buildings have been severely damaged.

ROAD CLOSURES
Washington Street from Fifth to Eighth Avenue has been closed.

SCHOOL CLOSURES
The Olympia North Thurston and Thurston schools are closed today.

WORKERS
A school district and workers who work on Thurston County have the day off, but Thurston County personnel shift today.

4th Ave. bridge Residents: 'Our building was dancing'

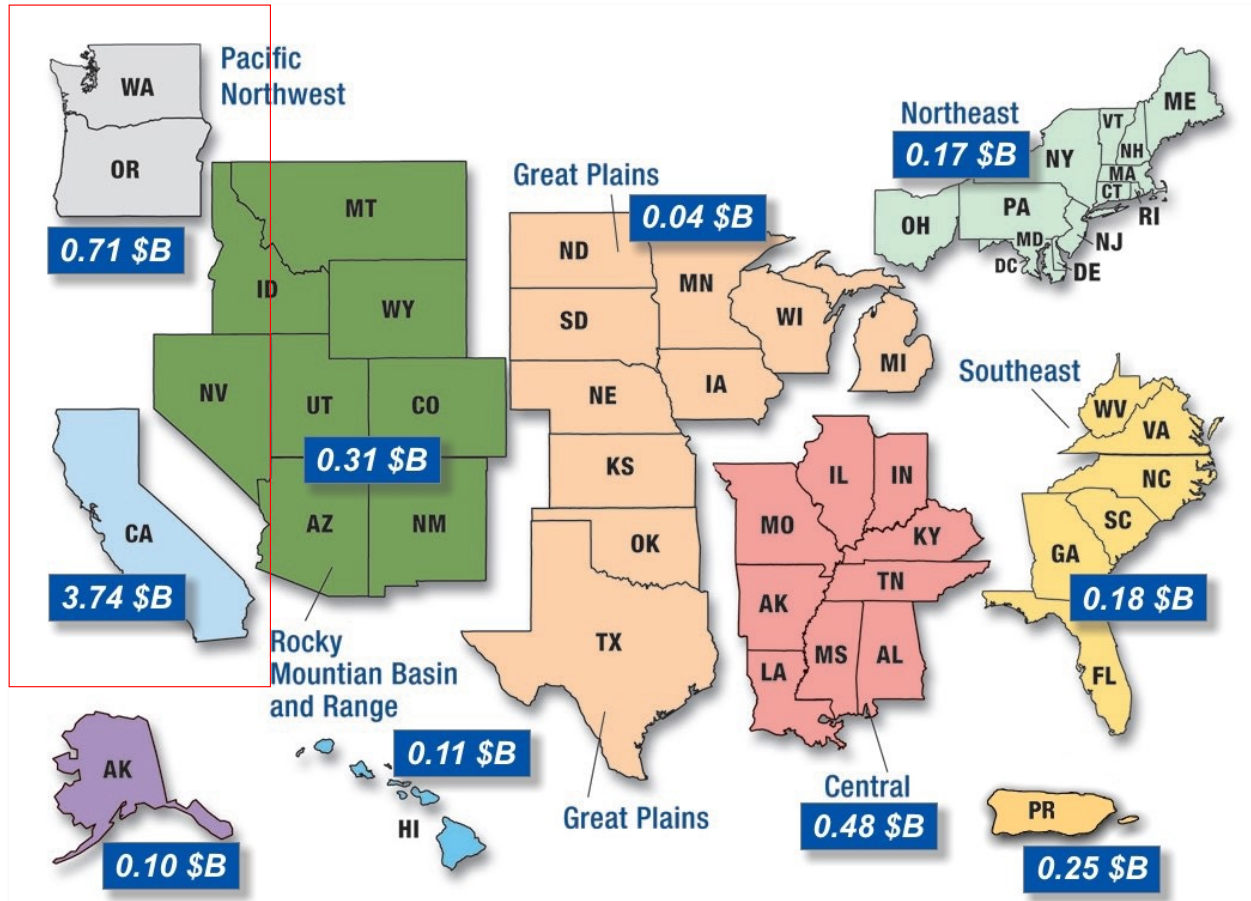
2001

Rubble from the downtown Washington Federal Savings building rests on the sidewalk off Fifth Avenue.

State buildings shut till Monday
BY PATRICK CONDON, BRAD SHANNON AND LAUREN WELSH
OLYMPIA—The earthquake that struck South Sound on Wednesday morning and then there was water pouring down the rubble strewn all over the city. It was a scene of devastation, with buildings that were once standing tall now in ruins. State buildings were shut for at least a week, and many employees were left without phones or offices to work in when the job market returned.

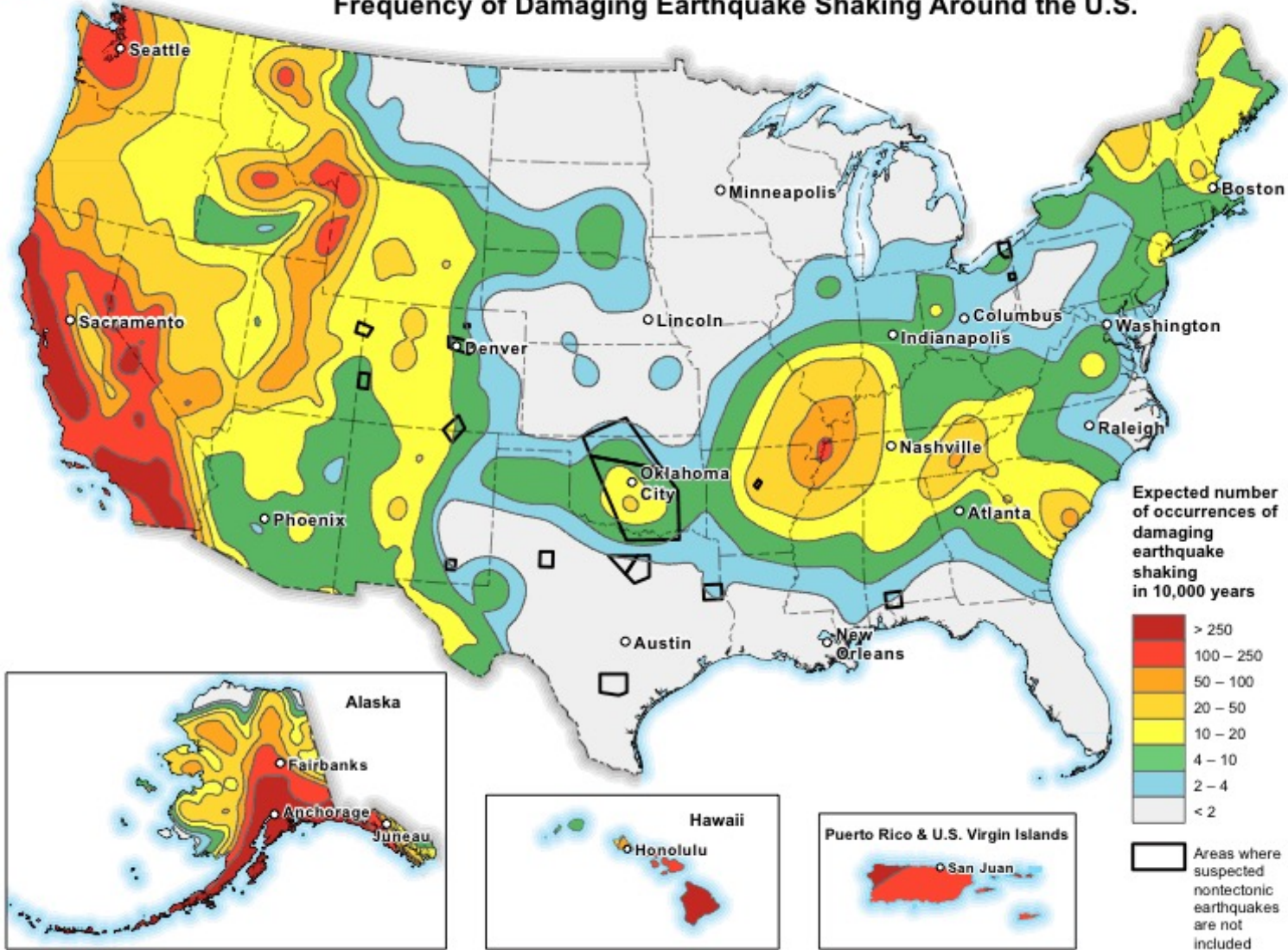
Annualized Earthquake Losses, \$6.1 billion

73% on West Coast (\$4.5B): \$710 million in PNW

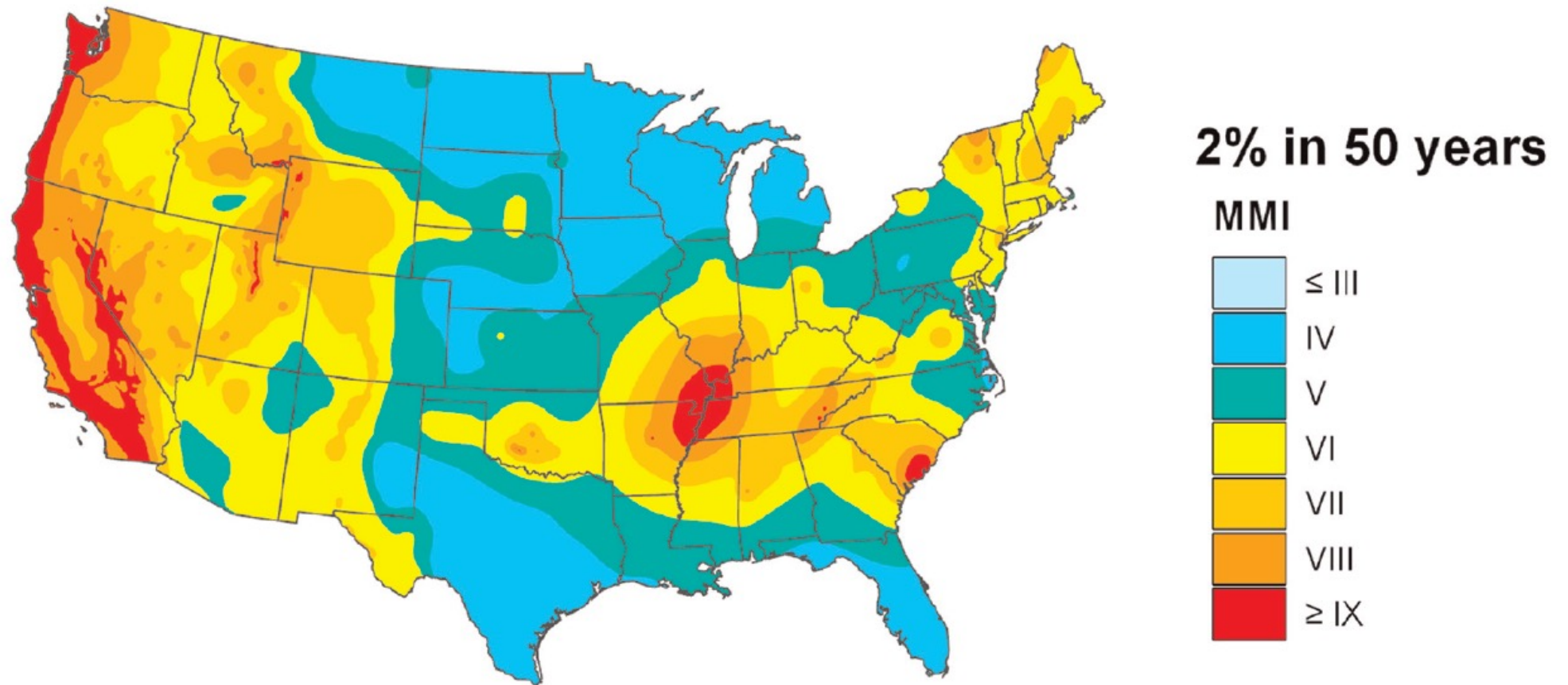


FEMA, P-366, 2017

Frequency of Damaging Earthquake Shaking Around the U.S.



USGS map showing the intensity of potential earthquake shaking above a 2% chance of happening in the next 50 years



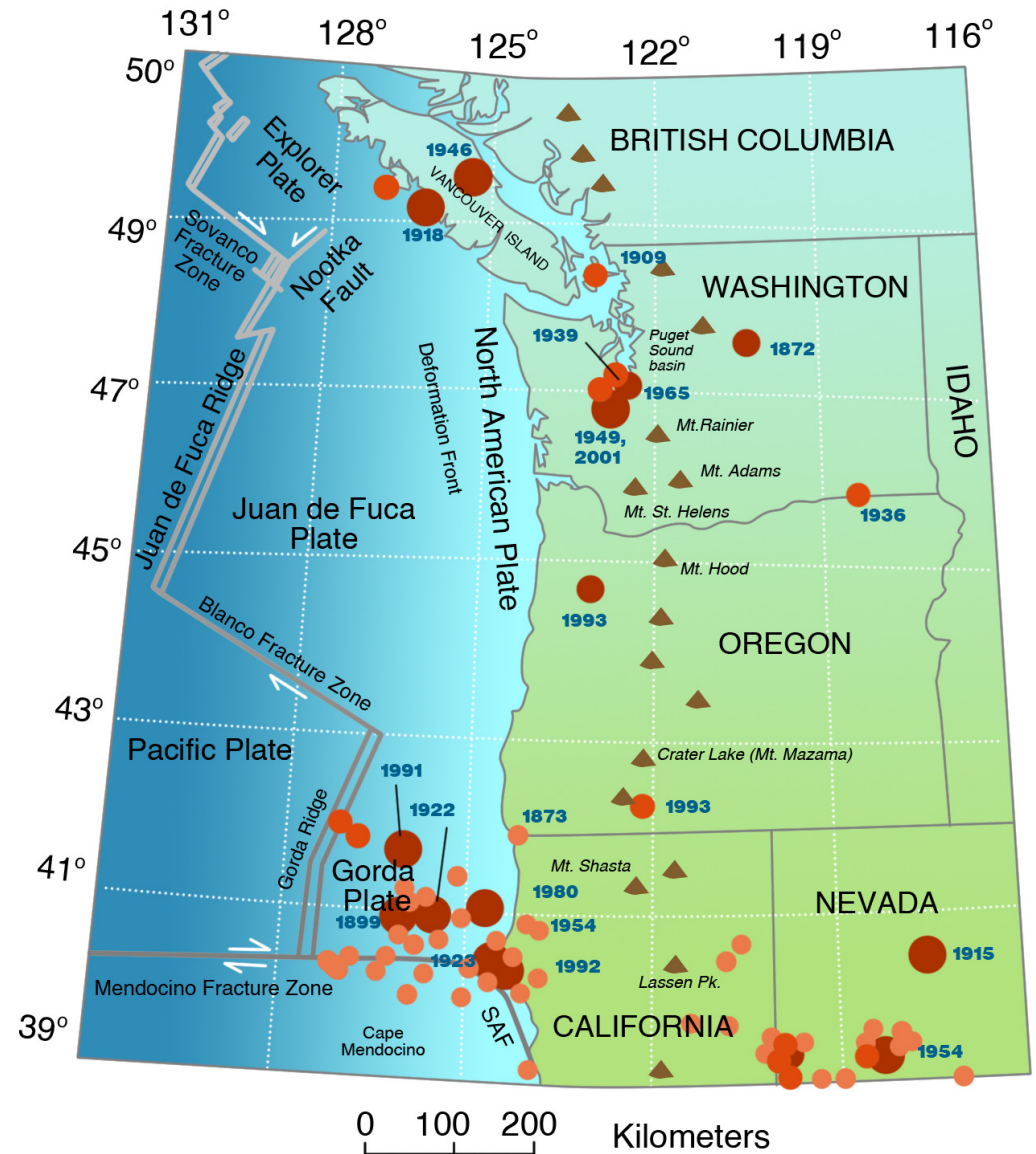
Historic large earthquakes 1833 – 2001

Most of the bigger ones were offshore and haven't had much impact

Deeper earthquakes in the southern Puget Sound have been the most common and damaging
1949, 1965, 2001

Largest so far (maybe): 1872 North Cascades - Lake Chelan quake

What about pre-historic?





The New Yorker

The Really Big One

by Kathryn Schultz

FEMA

Quote:

"We are
planning as
if everything
west of I-5
will be
toast."



We inhabit the Cascadia
subduction zone
One of the planet's tectonic plate
boundaries

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Data LDEO-Columbia, NSF, NOAA
© 2018 Google

Google Earth

33.7 mi

Imagery Date: 12/13/2015 45°45'02.09" N 125°10'06.79" W elev -4478 ft eye alt 96.00 mi

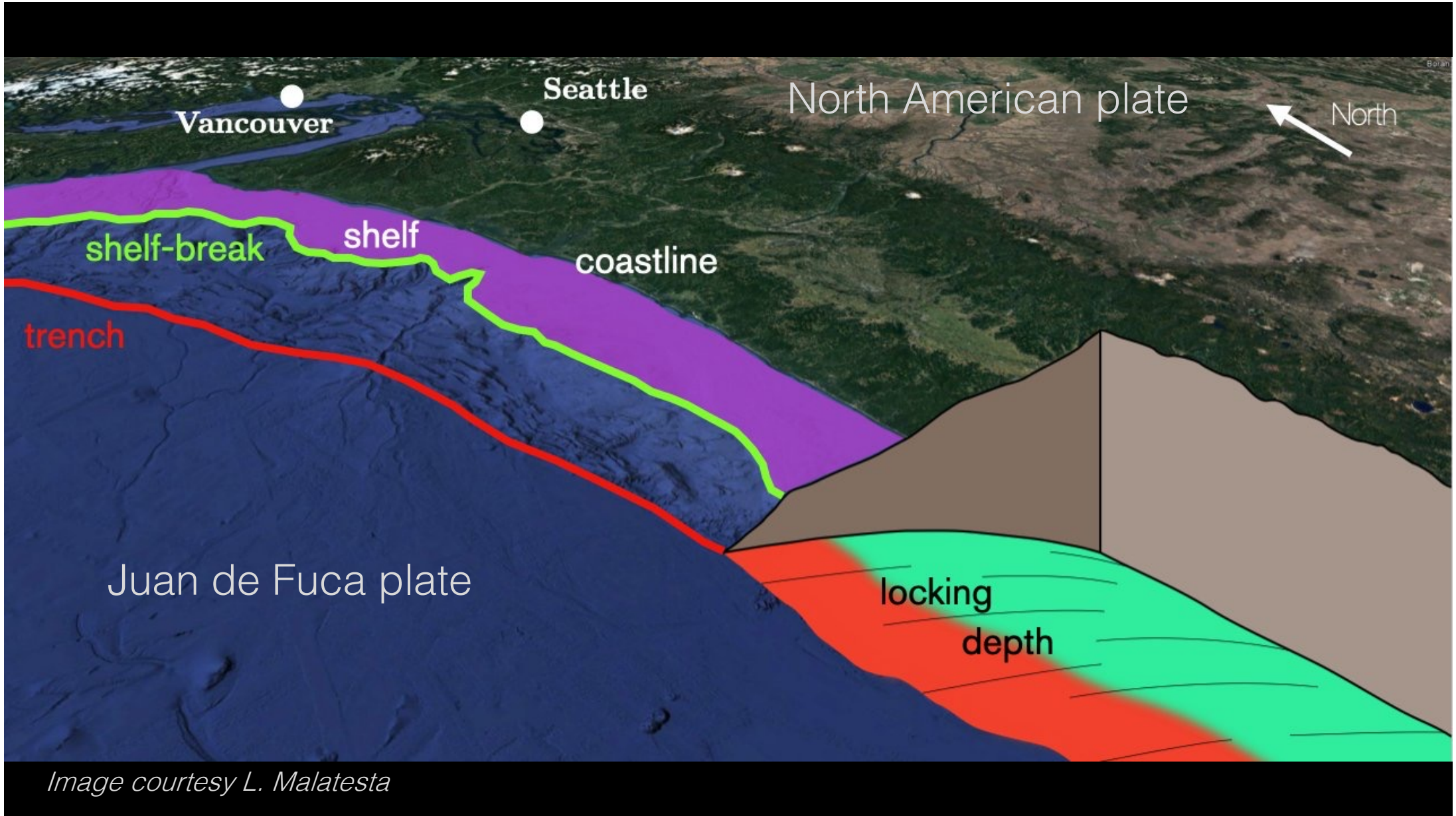
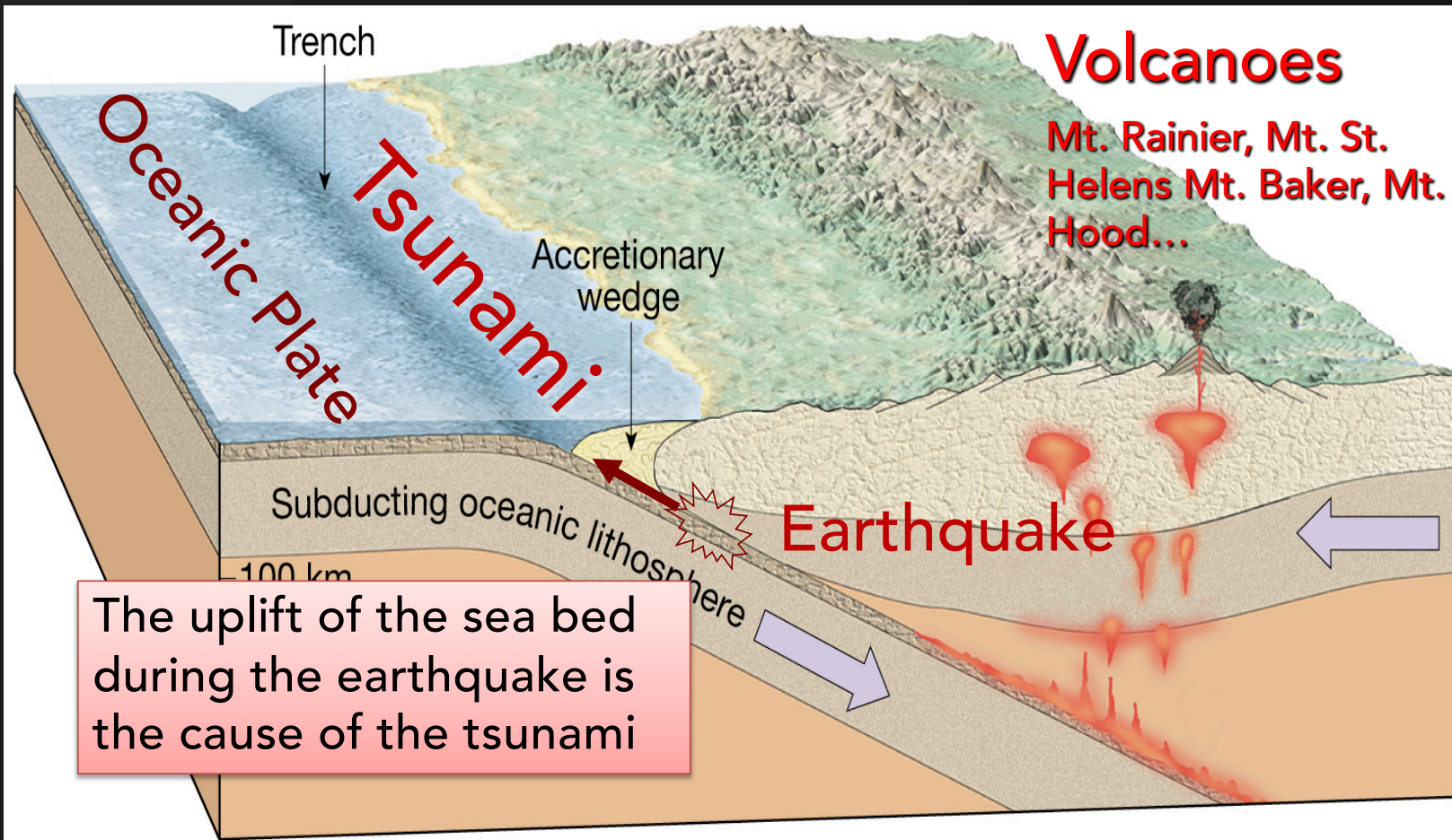


Image courtesy L. Malatesta

Subduction Zones like the Pacific Northwest* cause the largest earthquakes and tsunami



*or Alaska, Japan, Mexico, Guatemala, Nicaragua, El Salvador, Costa Rica, Colombia, Ecuador, Peru, Chile, Indonesia, Puerto Rico, Barbados, New Zealand, Tonga, Marianas, and more... !

March 11, 2011 in northern Japan

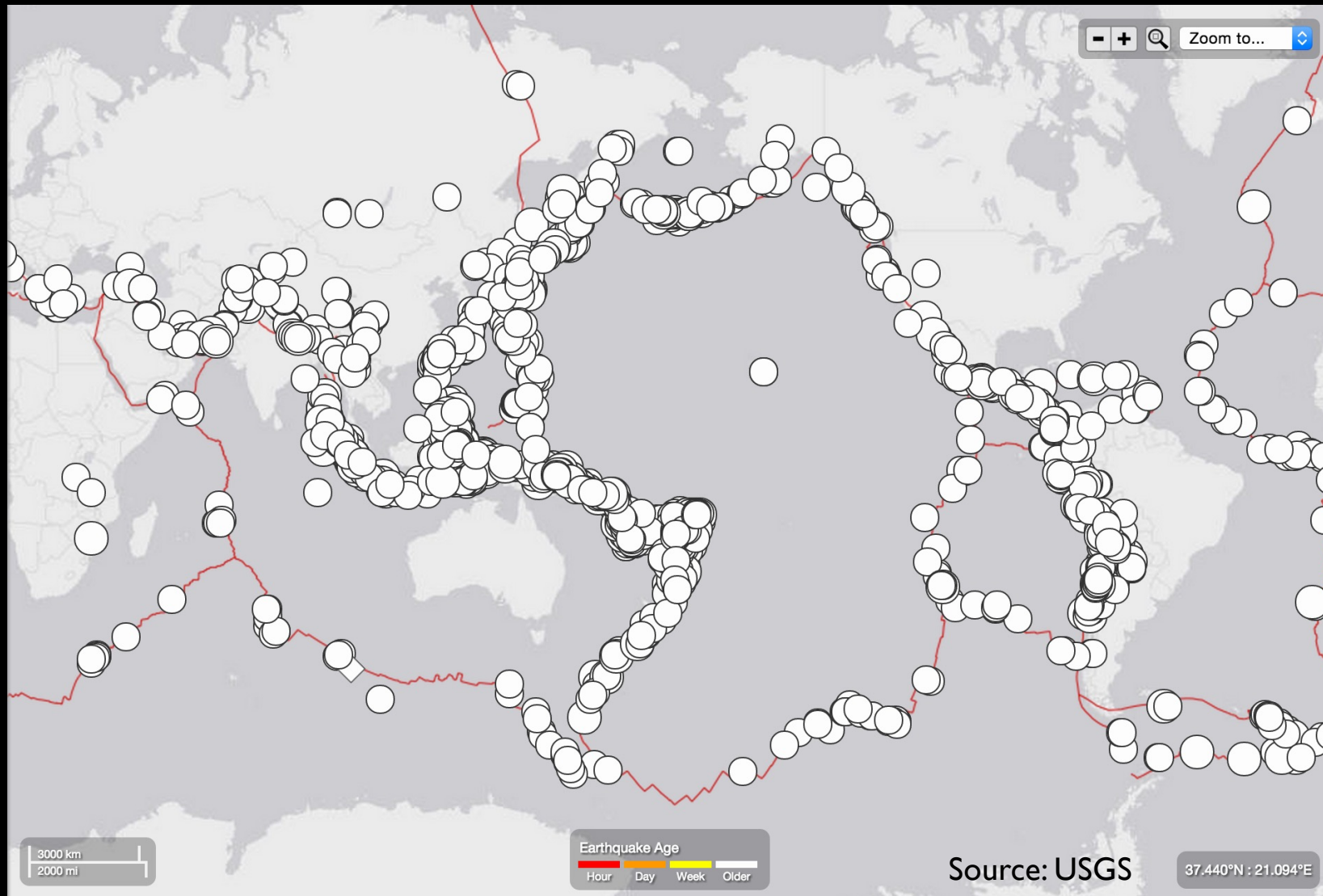
Civilization exists
by geological
consent, subject
to change without
notice.

– *Will Durant,*
historian

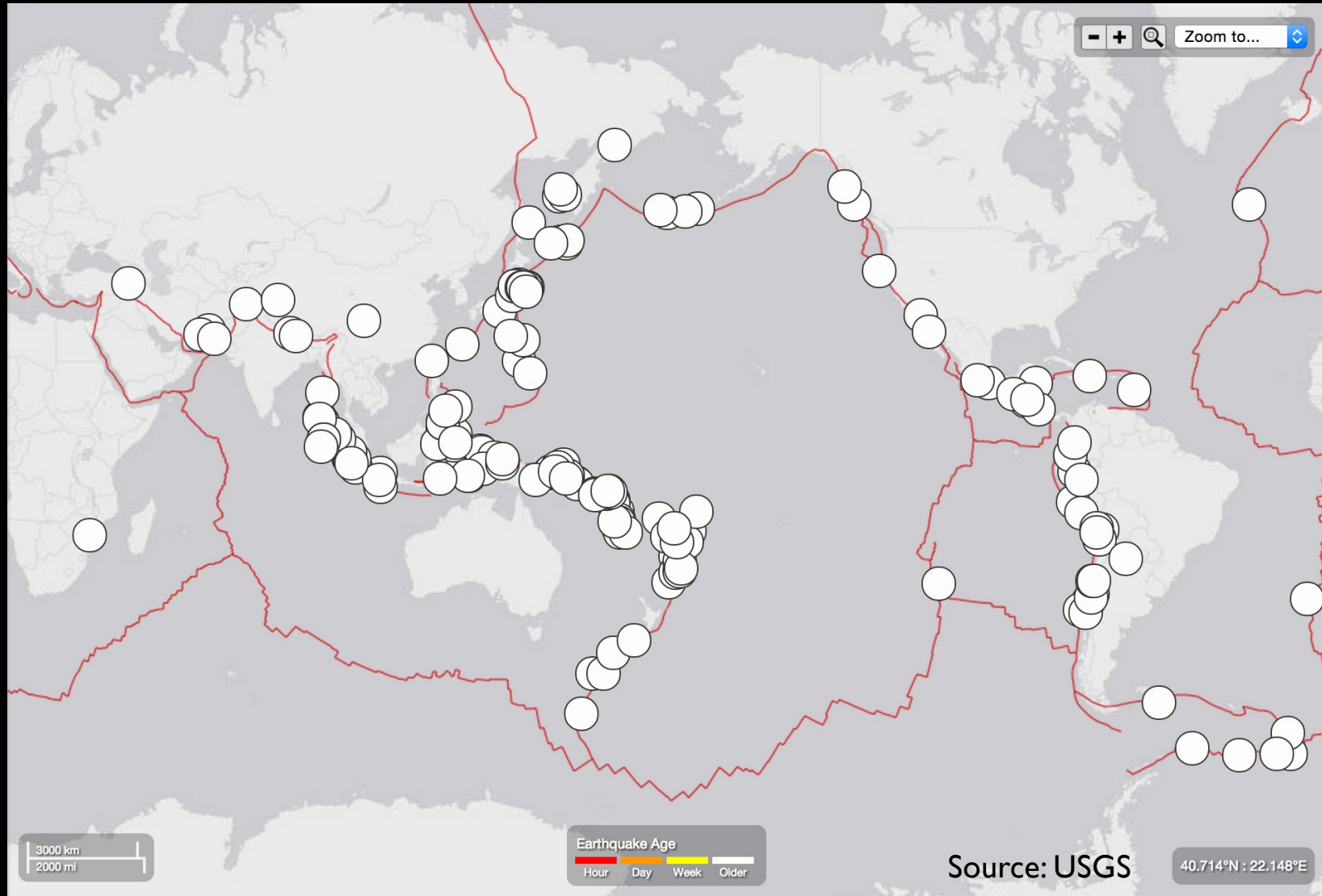
NHK news photo



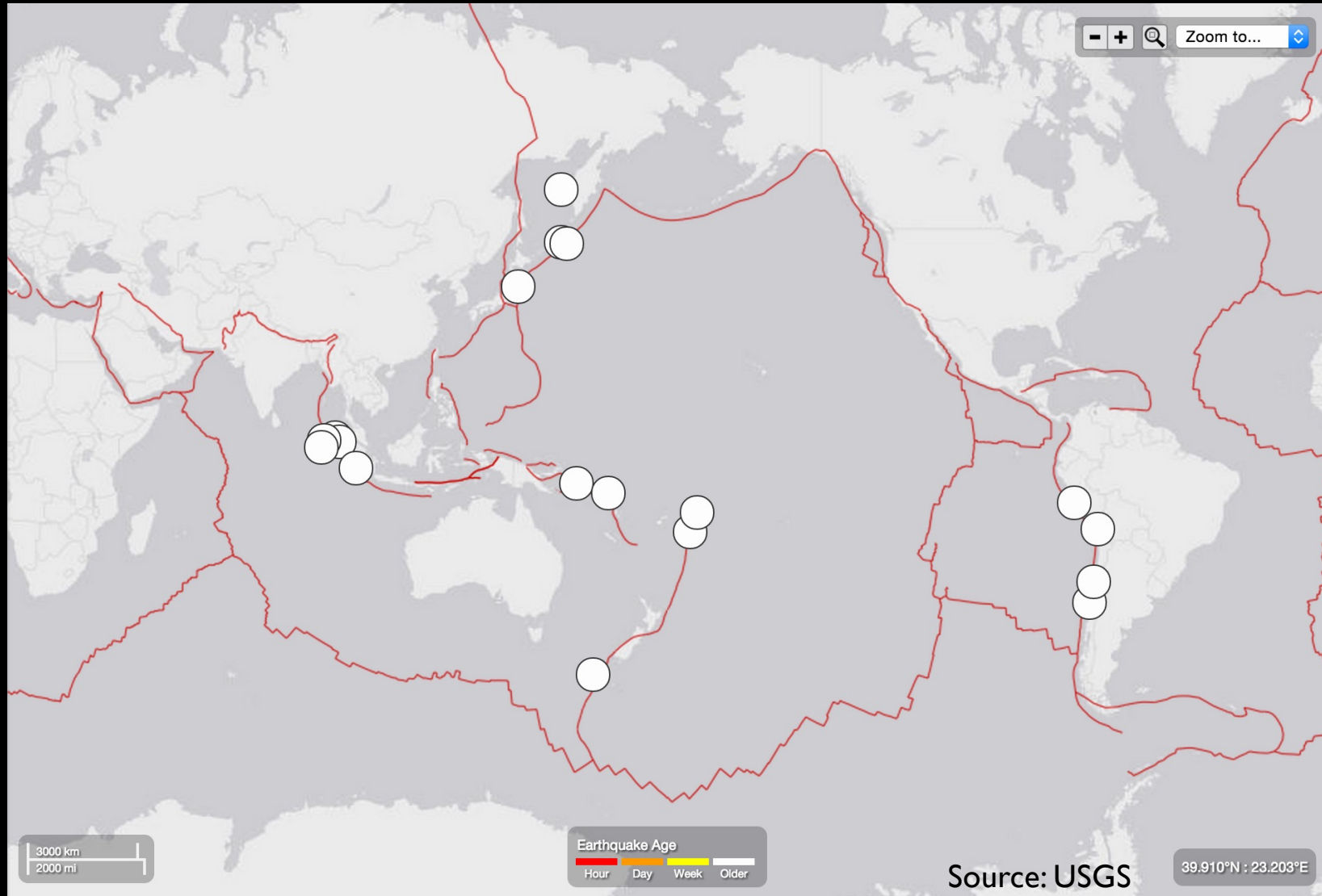
All 1800 earthquakes larger than magnitude 6 since 2004



All 181 earthquakes larger than magnitude 7 since 2004

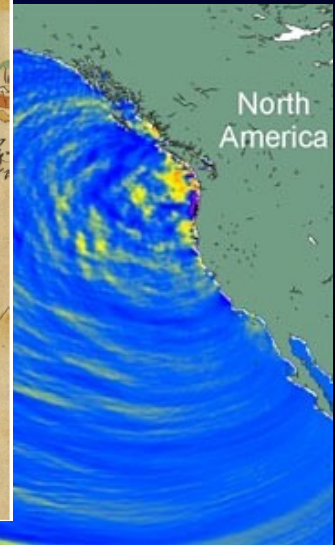


All 18 earthquakes larger than magnitude 8 since 2004

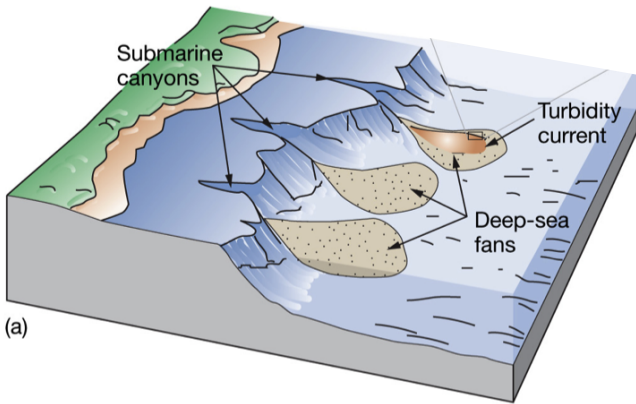


Jan 26, 1700 at about 9:30 pm:
magnitude 9 earthquake struck the Pacific Northwest

How do we know?

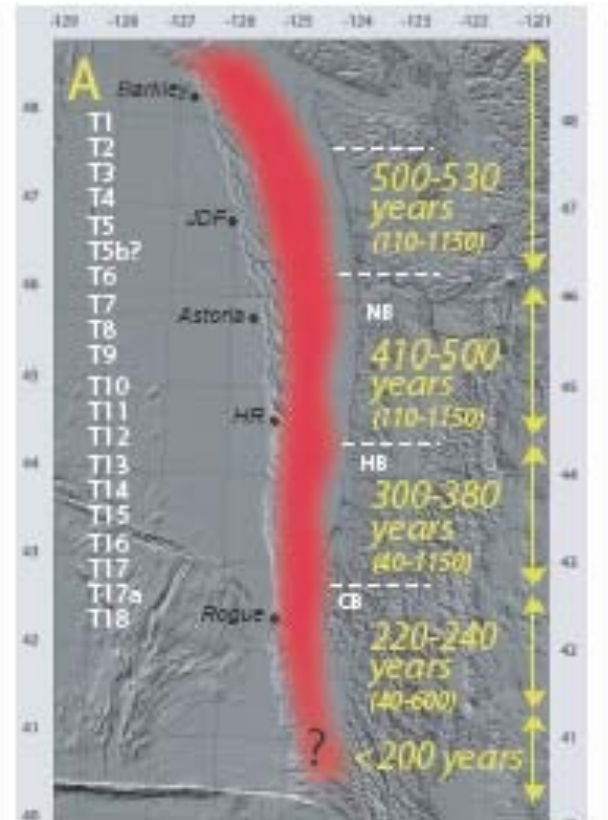


Last 10,000 years of great earthquakes deduced from offshore geology

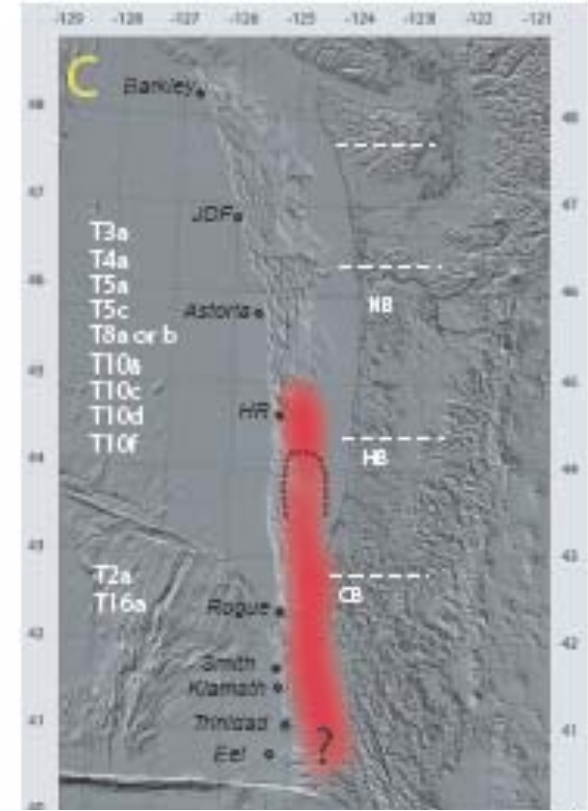


(a)

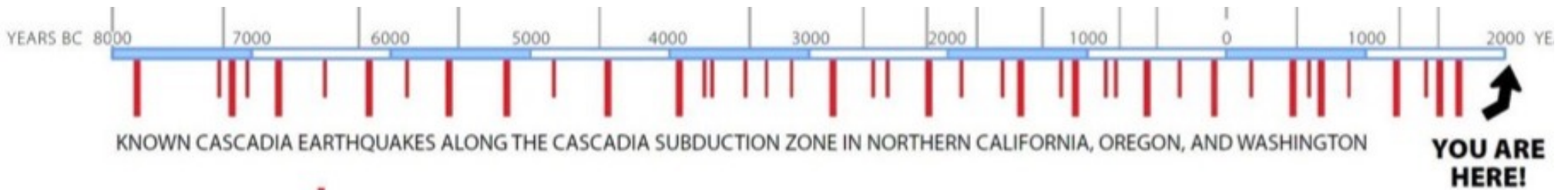
Copyright © 2008 Pearson Prentice Hall, Inc.



19 ~M9 events



20 ~M8 to M8.5 events



(Goldfinger et al., 2008, Bull. Seis. Soc. Amer)



Tsunami wave simulation

for Washington State
from a hypothetical
magnitude 9.0
earthquake
(L1) scenario
on the Cascadia
subduction zone



WASHINGTON STATE DEPT OF
**NATURAL
RESOURCES**
WASHINGTON
GEOLOGICAL SURVEY



National
Tsunami
Hazard
Mitigation
Program



Deep Slab Earthquakes

Magnitude 7-ish

Nisqually 2001

Our most common quake

~85% chance in 50 yr.

Cascadia Subduction Fault

Giant earthquake every
300-600 years

15 - 25% probability in next
50 years

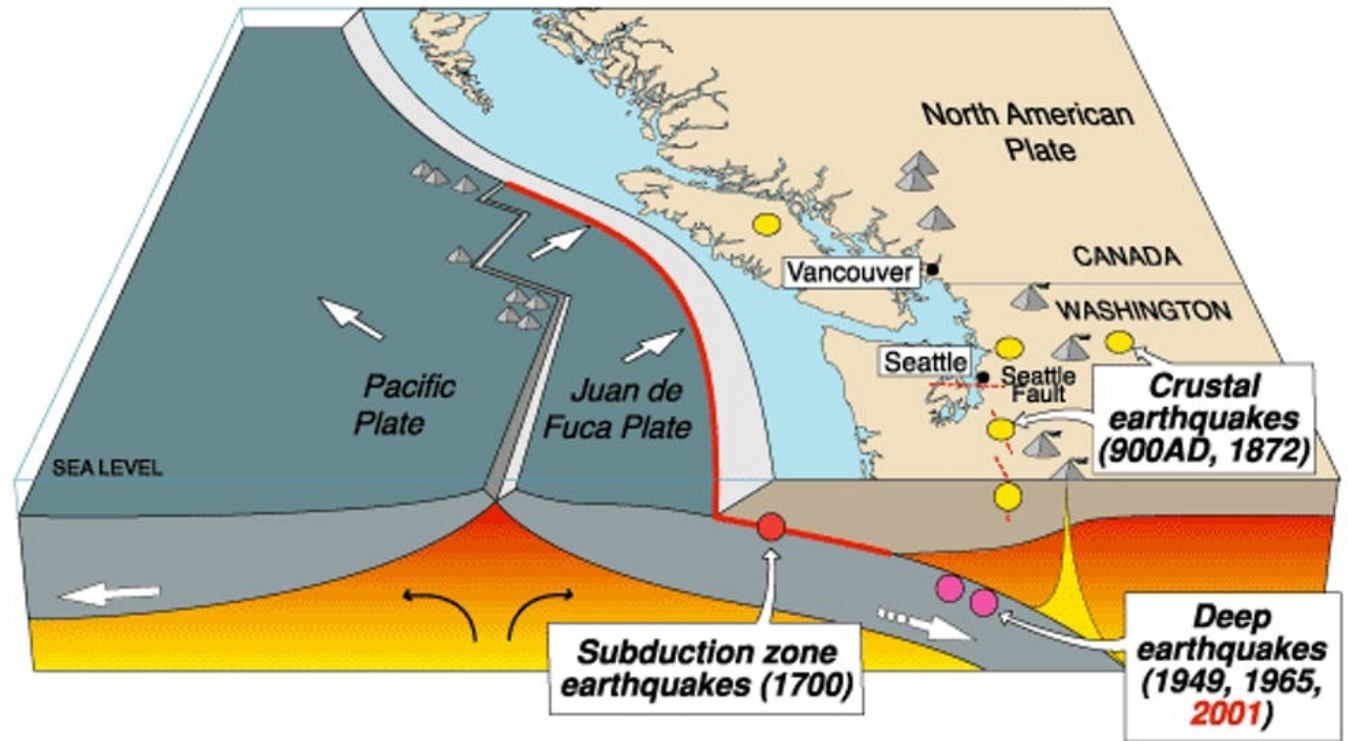
"Shallow" Crustal Faults

Magnitude 7-ish

1872 (largest historic)

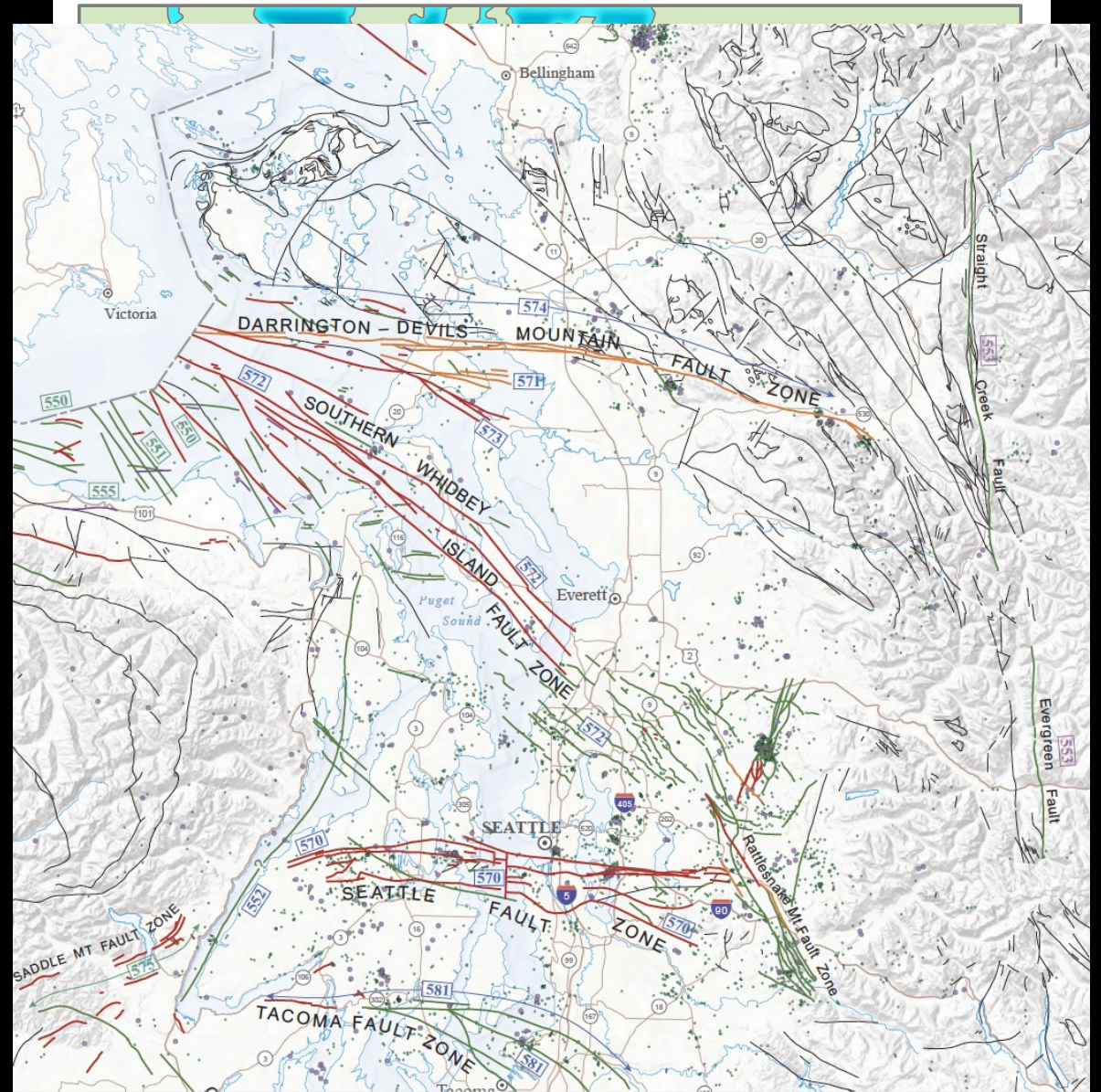
~15% probability in 50 yr.

How likely are major earthquakes?



There are a number of identified faults without large earthquakes in the historic record

- Tacoma Fault
- Seattle Fault
- Southern Whidbey Island Fault
- Darrington–Devils Mtn Fault



Seattle Fault

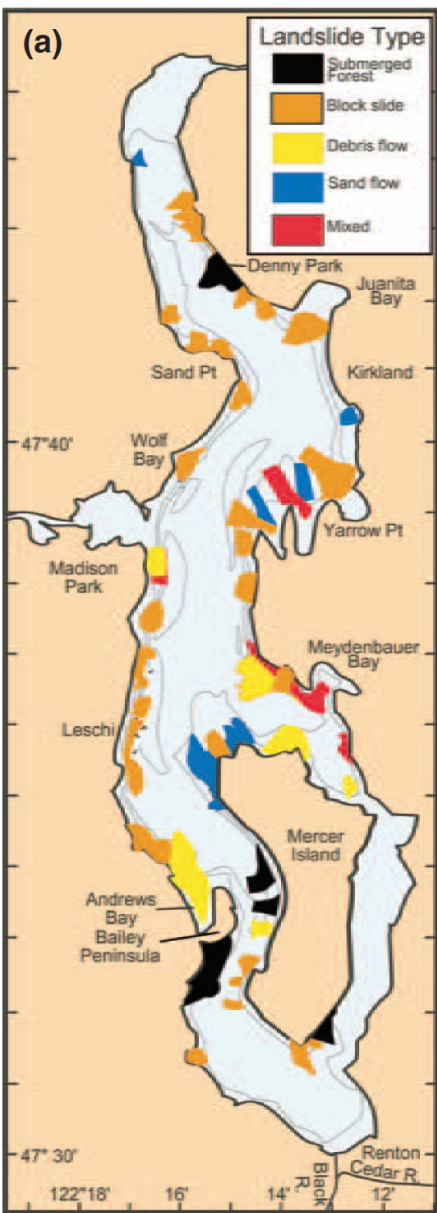


Lidar image of southern
Bainbridge Island near
Seattle and the "Toe Jam
Hill" fault

Seattle Fault Zone

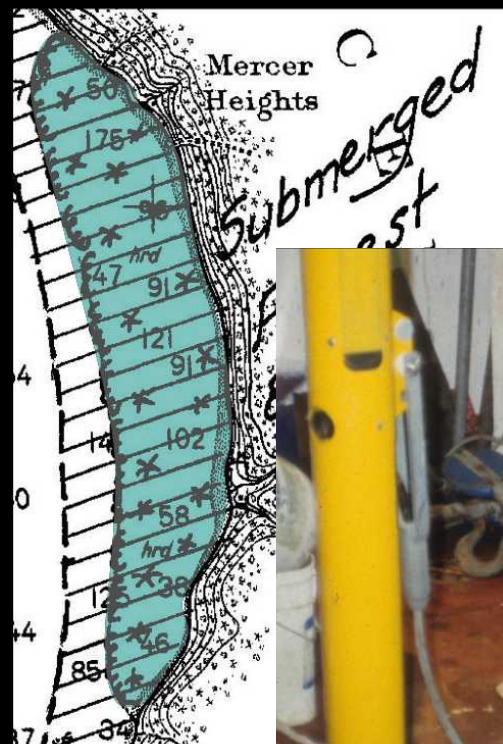
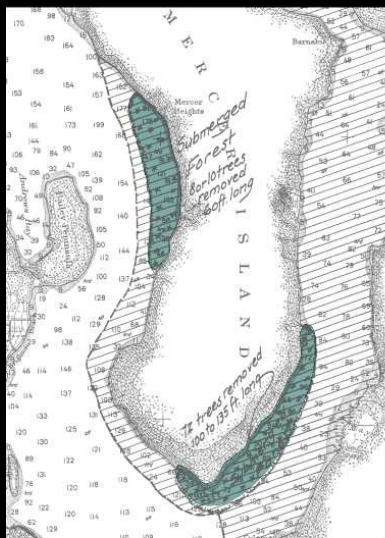
Large earthquake
900–930 C.E.





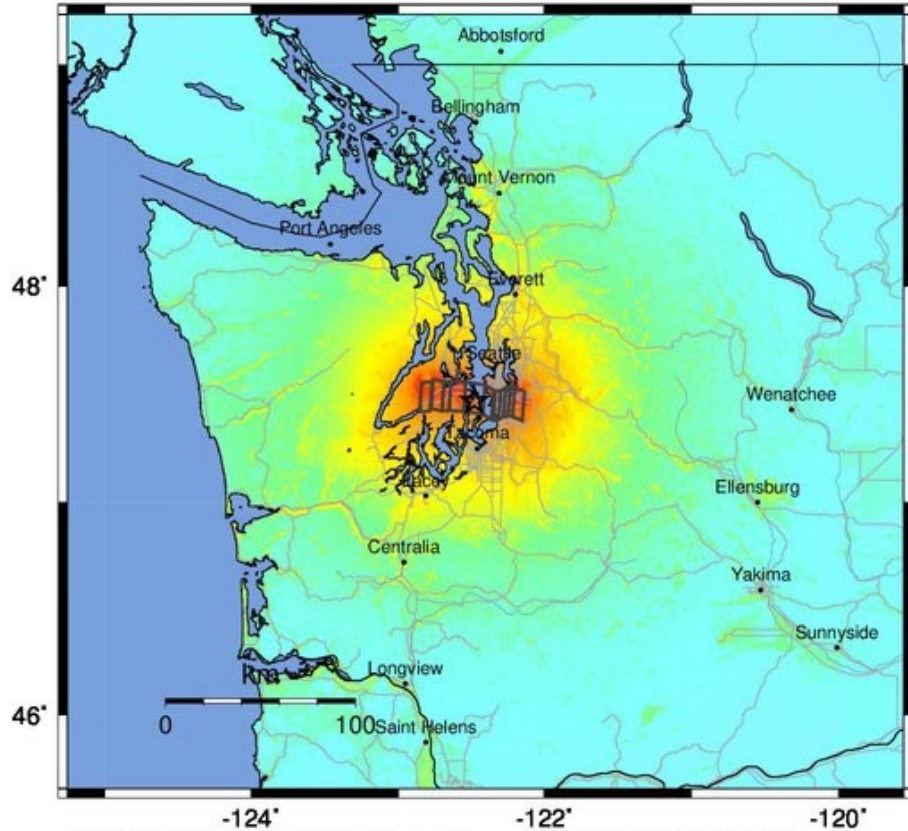
Prehistoric Landslides and submerged forests in Lake Washington tied to earthquake in 900 – 930 AD (1100 years ago)

Mercer Island



Notes and symbols added in

-- Earthquake Planning Scenario --
ShakeMap for Seattle fault zone-southern - Median ground motions Scenario
 Scenario Date: May 12, 2017 02:14:14 PM MDT M 7.2 N47.47 W122.48 Depth: 9.0km

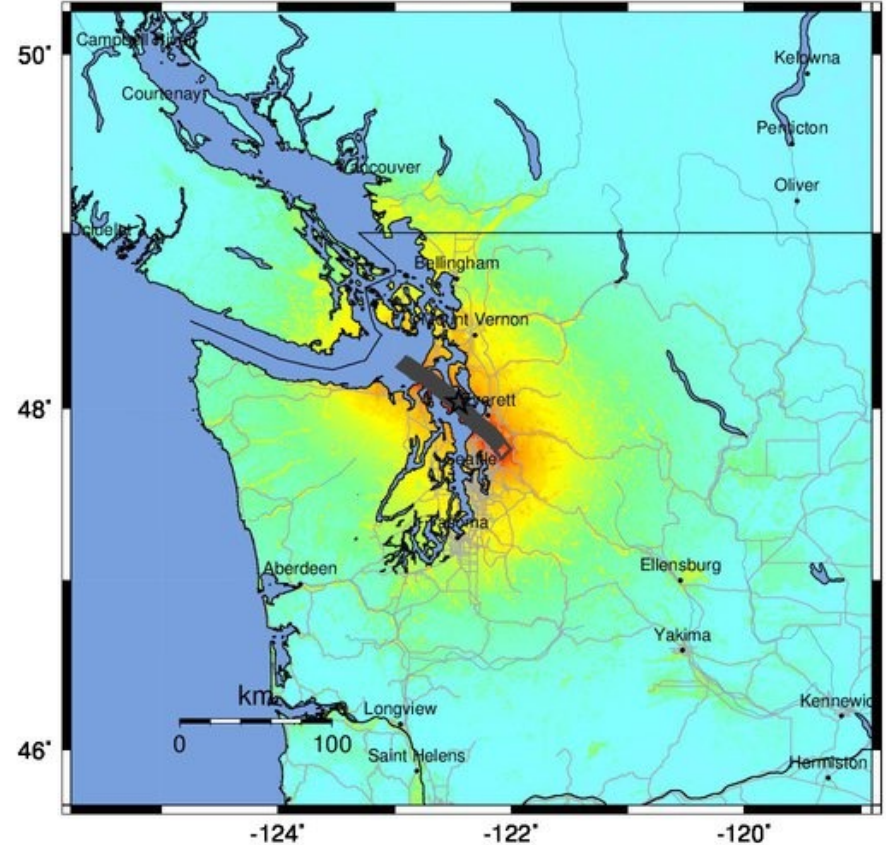


PLANNING SCENARIO ONLY -- Map Version 3 Processed 2017-05-15 09:31:26 PM MDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	<0.02	0.1	1.4	4.7	9.6	20	41	86	>178
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2012)

-- Earthquake Planning Scenario --
ShakeMap for Southern Whidbey Island fault-southern - Median ground motions Scenario
 Scenario Date: May 12, 2017 02:14:09 PM MDT M 7.4 N48.04 W122.45 Depth: 9.0km



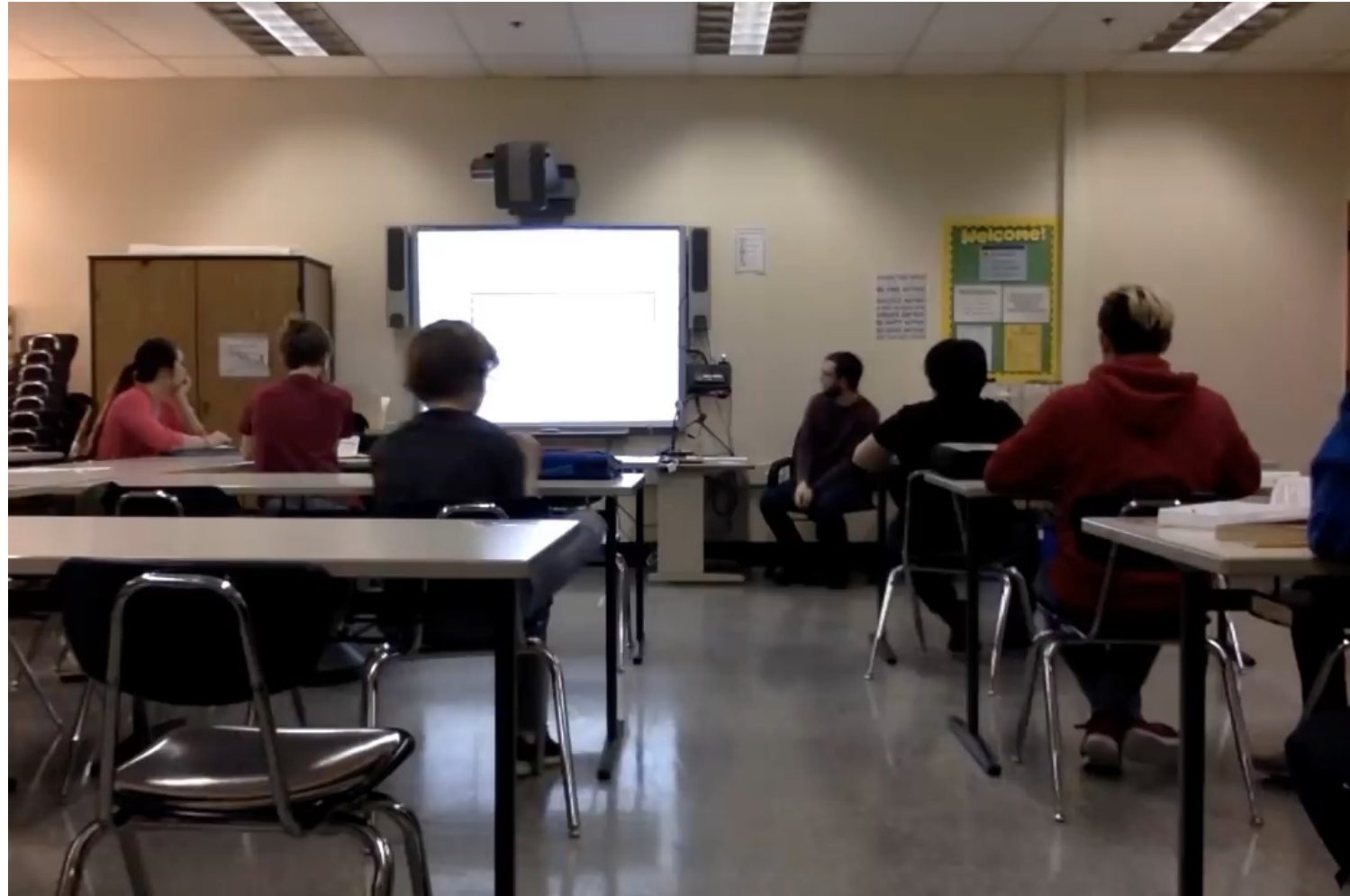
PLANNING SCENARIO ONLY -- Map Version 3 Processed 2017-05-15 10:14:38 PM MDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
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INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2012)

Earthquakes are inevitable. How do we lessen their effects?

- Resilient construction: Retrofits and Building Codes
- Life safety: Drop, cover, hold on
- Earthquake Early Warning – the newest tool we have

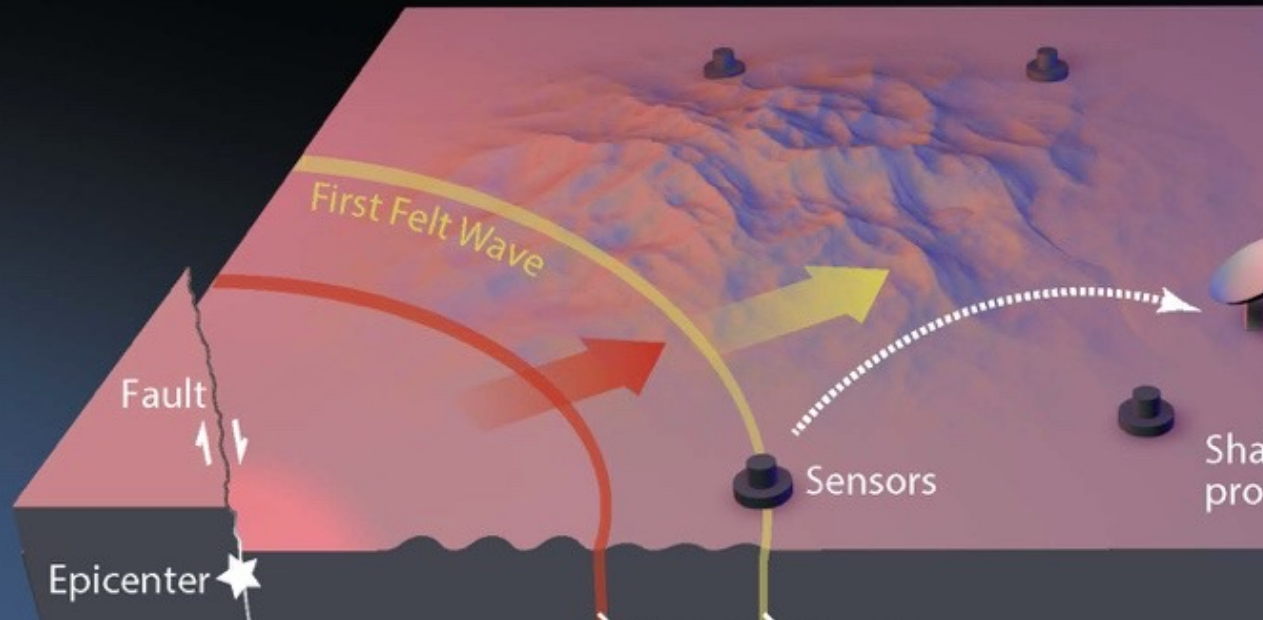


30 years ago: October 17, 1989 at 5:04 pm
University of California Santa Cruz

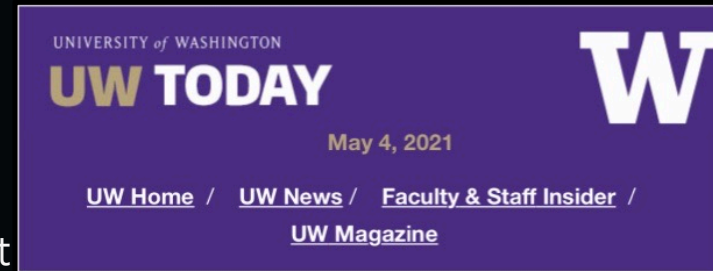


How it works:

- Earthquakes send out different types of seismic waves: **fast ones** that don't cause damage, and **slower ones** that do
- Detectors near the fault can send data **much faster** than seismic waves travel
- Computers identify onset of quake, locate it, and calculate magnitude and expected shaking intensity → *create alert*



West



Earthquake early warnings launch in Washington, completing West Coast-wide ShakeAlert system

When the Big One hits, the first thing Washington residents notice may not be the ground shaking but their phone issuing

Wt™

/stem

ngton
altech
rkeley
regon

t



ShakeAlert™ example using 2001 Nisqually epicenter



P wave = 6 km/sec (3.7 mi/sec)
S wave = 4 km/sec (2.5 mi/sec)



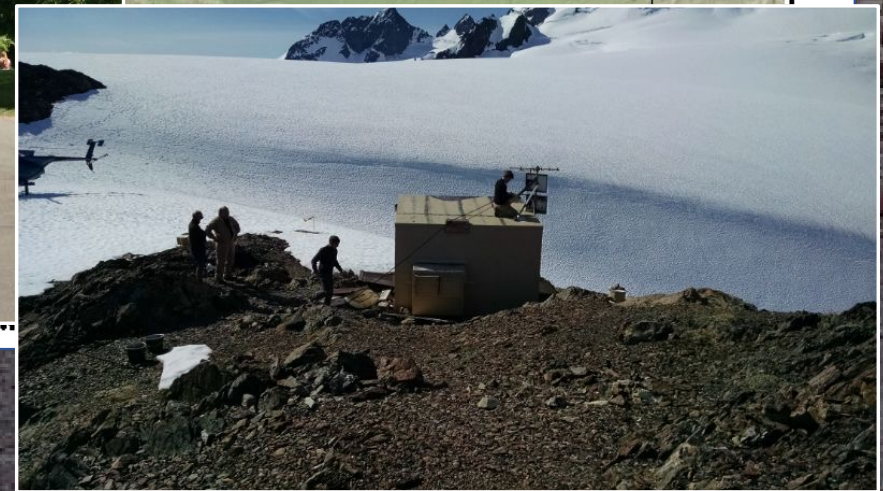
Data Processing Center



PNSN

- We operate 238 seismometers in WA alone to detect the onset of earthquakes in seconds
- Data streams in to computers at UW in Seattle that detect the quakes and issue the alerts
- If minimum severity is met (magnitude and intensity) then alert is delivered by:
 - WEA emergency alerts
 - Android phone natively

W
UNIVERSITY of WASHINGTON

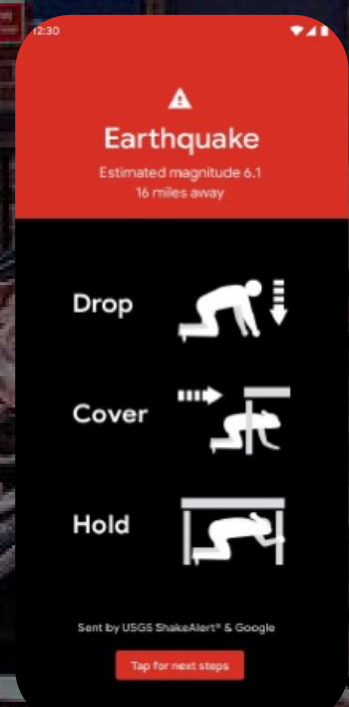


PNSN



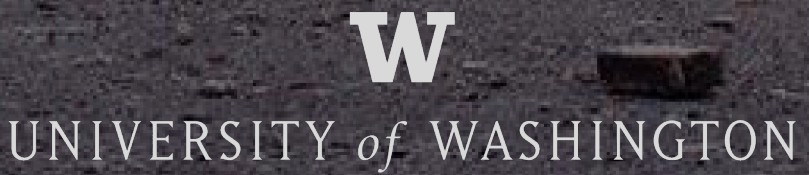
- Alerts delivered to mobile devices in 2 ways: WEA and through native smartphone software
- Experience in California has shown it works

• For instructions on how to check your phone:
mil.wa.gov/alerts



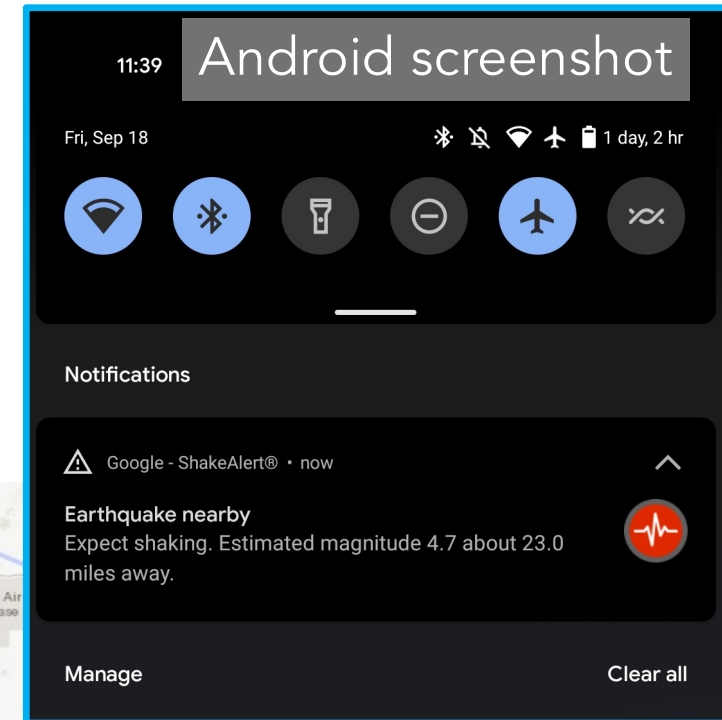
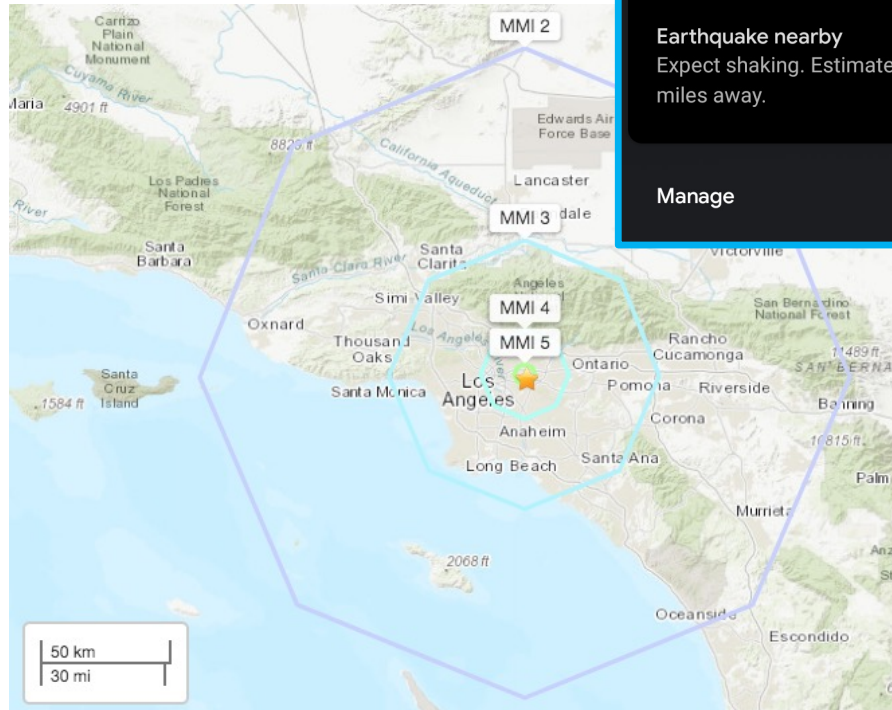
Wireless
Emergency Alert
(cell carriers)
Sent via FEMA's IPAWS
(Integrated Public Alert and
Warning System, e.g. AMBER)

Android Alerts (Google)
(40% of smartphones in U.S.)
3 alert levels:
• 'Take Action' (MMI 5+)
• 'Be aware' (MMI 3-4)
• 'Earthquake Occurred'



September 18, 2020: magnitude 4.6 in Los Angeles

- Initial alert release **4.7 seconds** after earthquake began
- *2.2 million* cell phone users were alerted, giving them a chance to take protective action.



What can you do with Seconds of Warning?

1. *Take Personal Action*
2. *Automate!*

ShakeAlert-approved partners across Washington already automatically take protective action and initiate automated controls to protect critical infrastructure.

Others are **internally testing (piloting)** their ability to use the ShakeAlert message to protect people and infrastructure.



Sammamish Utility first to install earthquake early warning technology



July 10, 2018 at 7:57 pm PDT

By Essex Porter, KIRO 7 News

SAMMAMISH, Wash. — The Northeast Sammamish Water District is trying out earthquake early warning technology at a pumping station that sits on top of a half-million gallons of water.

A simulation shows us what would happen if an earthquake were detected by the Pacific Northwest Seismic Network.

Example ShakeAlert implementations already installed in Washington





Because seconds matter.

Public alerting is now live across all 3 west coast states

WEA and Android systems are ON for your device by default, unless you have turned them off.

Learn how to check your settings at:

mil.wa.gov/alerts.

No downloads are needed



More at:

<https://pnsn.org/blog>

Reach out to us for more information:

pnsn@uw.edu

www.pnsn.org

Opinion

Lawmakers' neglect of school seismic safety risks children's lives

Jan. 11, 2022 at 2:59 pm | Updated Jan. 11, 2022 at 2:59 pm

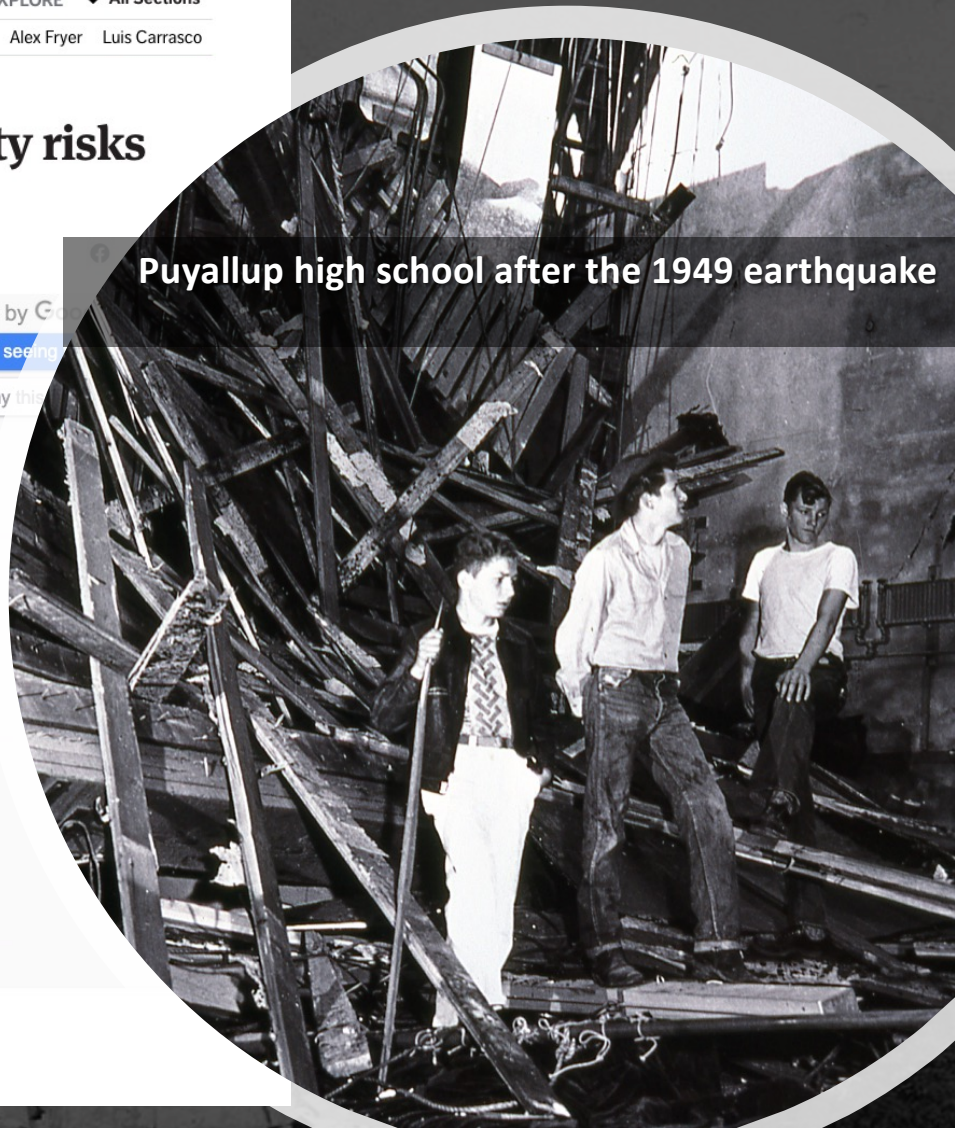


Fourth graders practice their drop, cover and hold-on skills during an annual earthquake drill at Genesee Hill Elementary in Seattle on Oct. 19, 2017. (AP Photo / Elaine Thompson, File)

By [Jim Buck](#)

Special to The Times

The 2022 Legislative session started this week with nearly a billion dollars of surplus revenue. It's no surprise the money is burning a hole in Olympia's pocket. It seems everyone in town has a pet project. But not one addresses the earthquake threat facing thousands of children attending older, unsafe public schools throughout Washington.



Puyallup high school after the 1949 earthquake

Ads by G
Stop seeing
Why this



www.pnsn.org

Harold Tobin: htobin@uw.edu