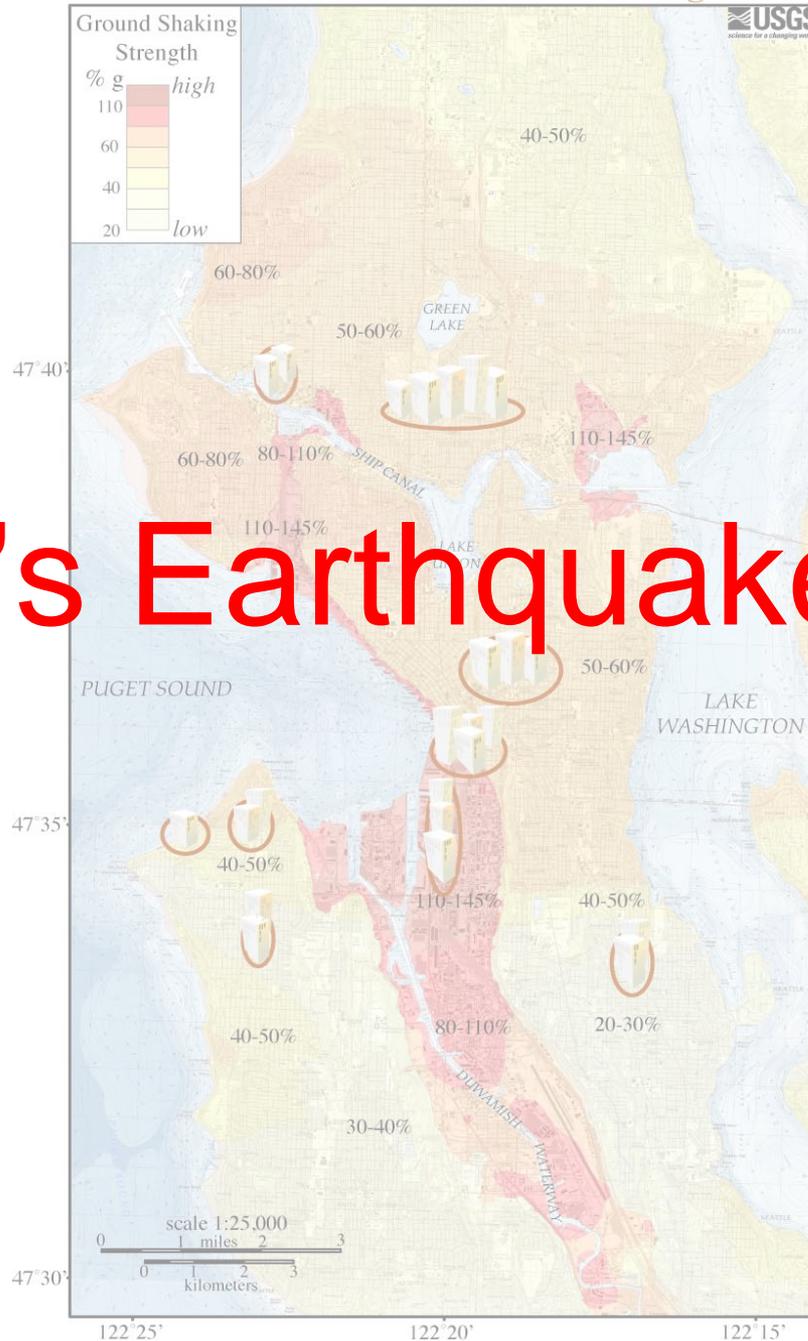
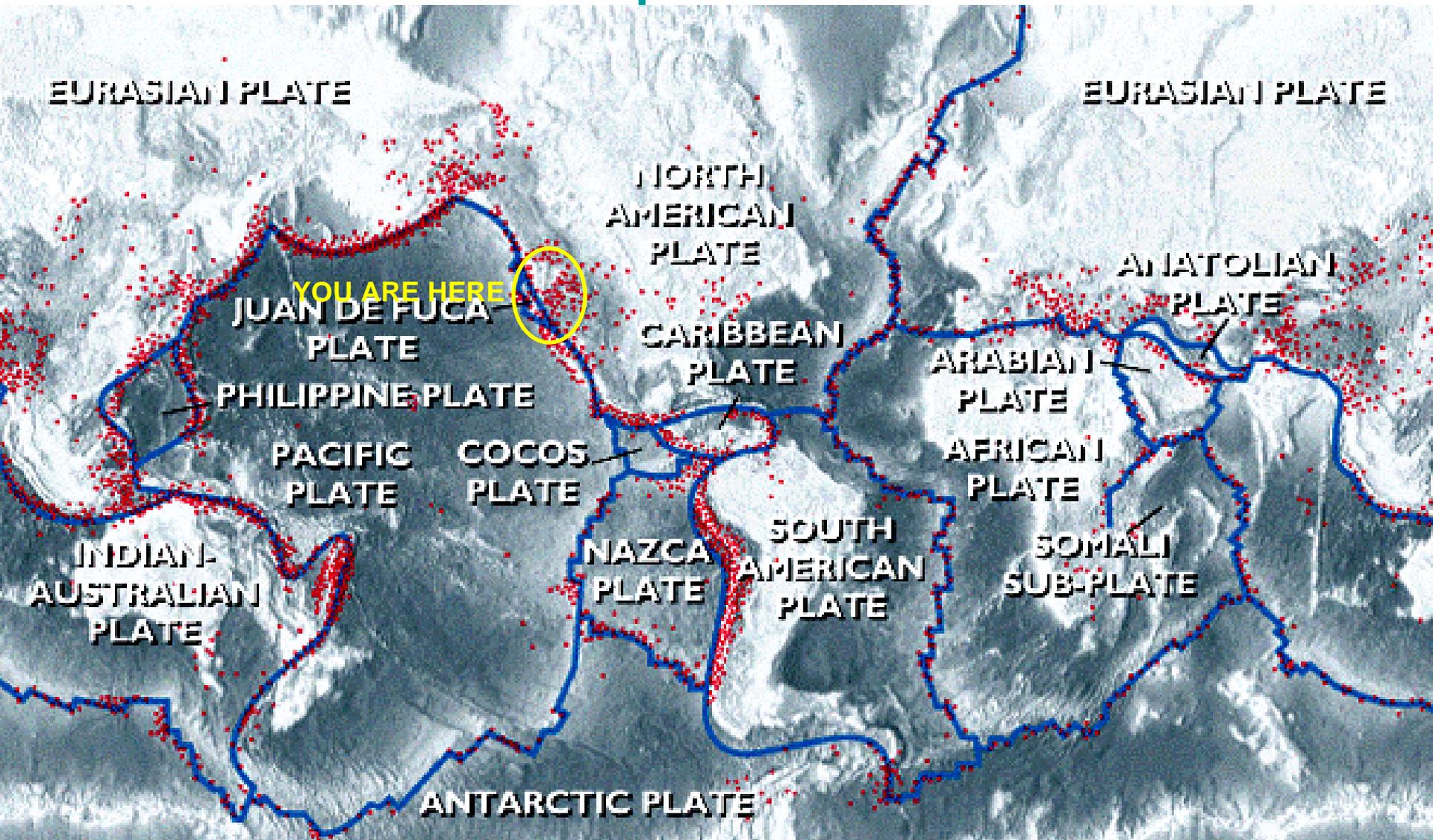


Seattle Earthquake Hazard (10% probability in 50 yrs) & Its Most Vulnerable Buildings



Seattle's Earthquake Hazard

Most earthquakes occur at tectonic plate boundaries





YOU ARE HERE

NORTH AMERICAN
PLATE

JUAN
DE FUCA
PLATE

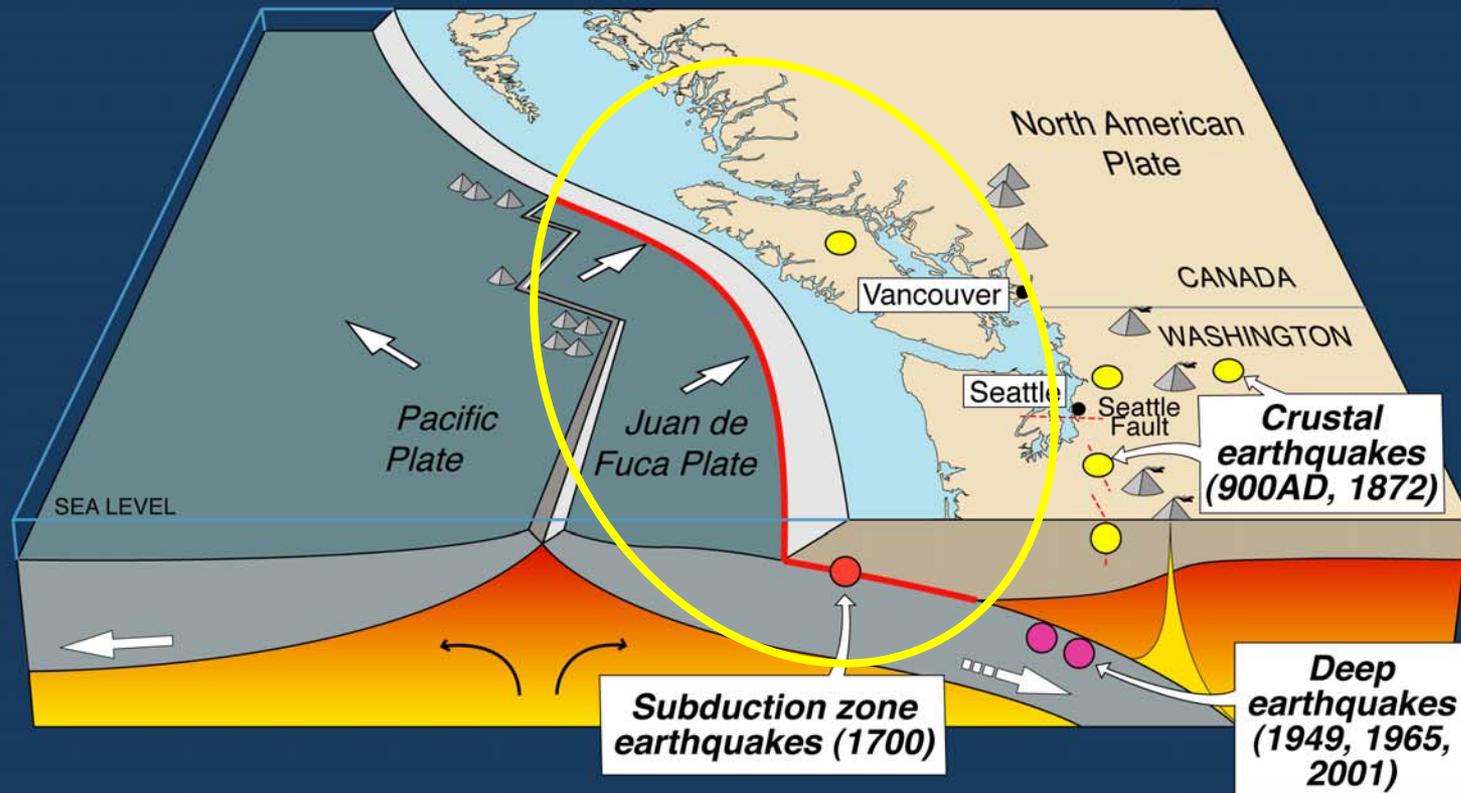
PACIFIC PLATE

2.4

2.7

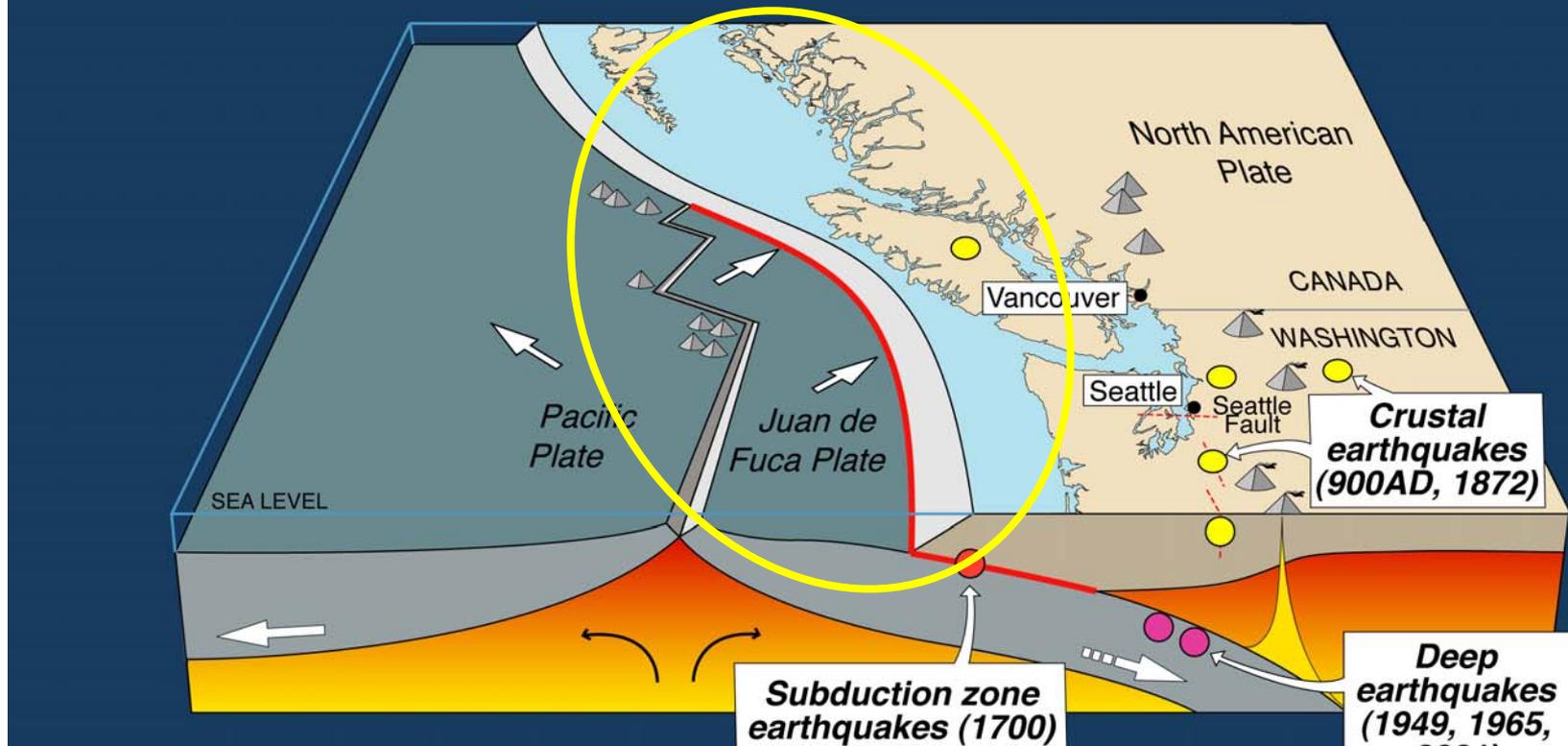
8.1

Cascadia earthquake sources



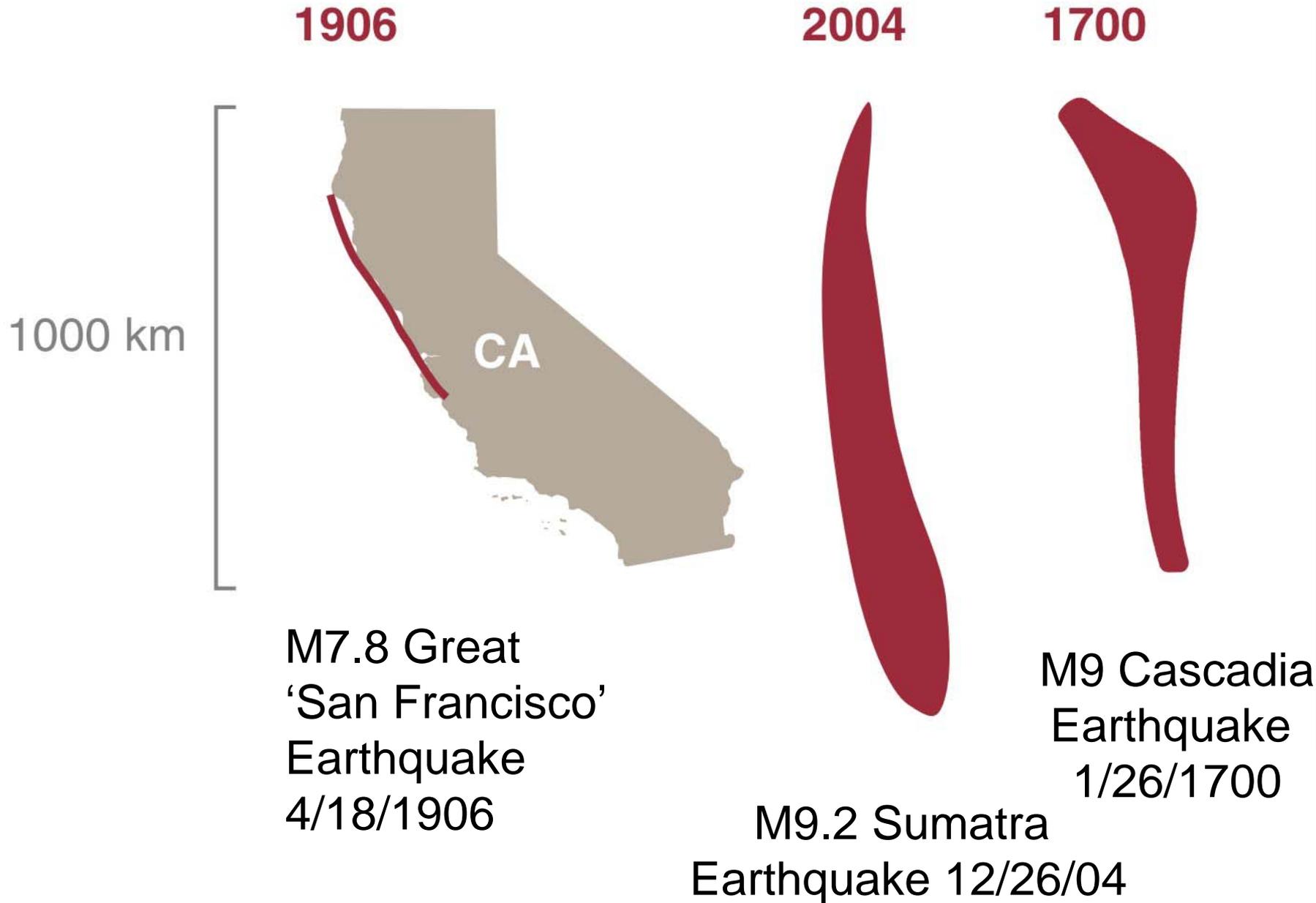
'Subduction zone' earthquakes are the BIG ONES, occurring where the downgoing plate is usually stuck.

Cascadia earthquake sources



In a 50-year window, there's a 10-14% chance of a M9 subduction zone earthquake.

Fault dimensions



20 meters (~60 feet) of motion in seconds!

1906

2004

1700



M7.8 Great
'San Francisco'
Earthquake
4/18/1906



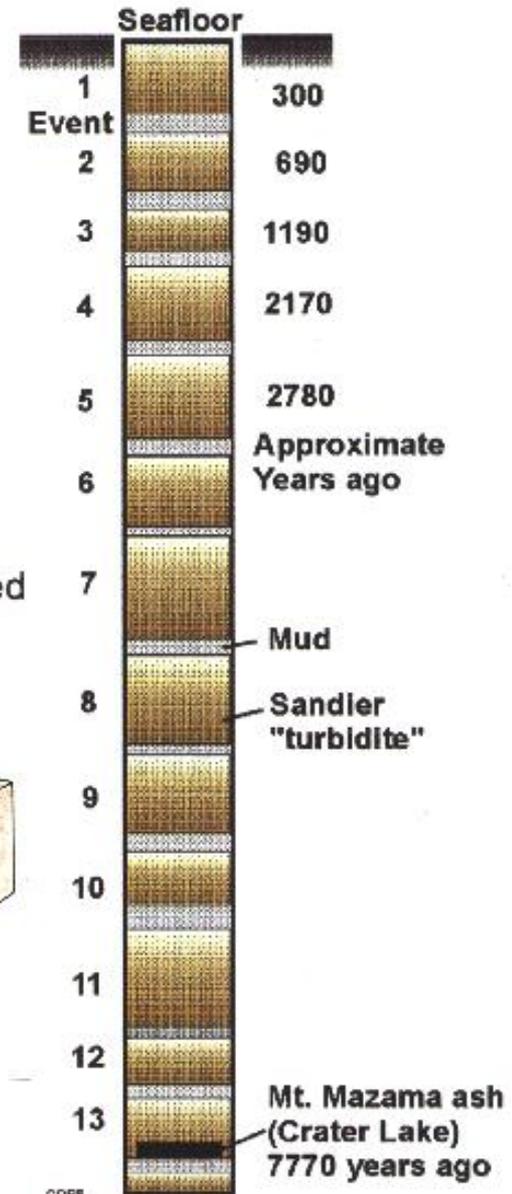
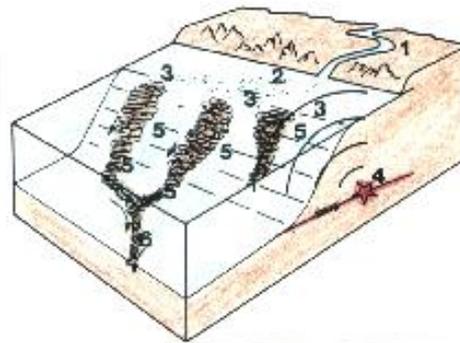
M9.2 Sumatra
Earthquake 12/26/04



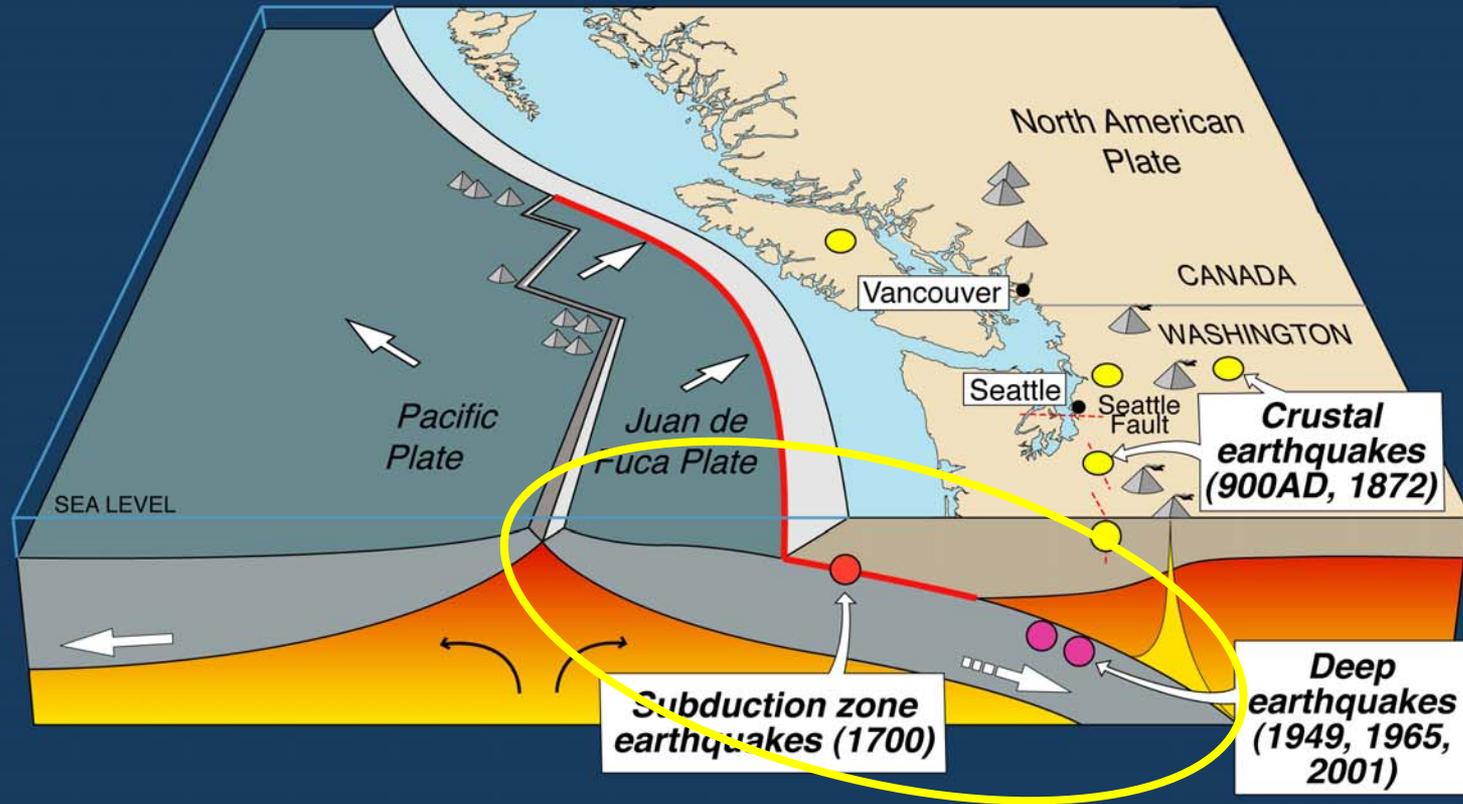
M9 Cascadia
Earthquake
1/26/1700

Mud on the sea-bottom keeps a record of many great earthquakes.

Cascadia deep sea sediment core showing great earthquake-induced sedimentation events (After Adams, 1990)

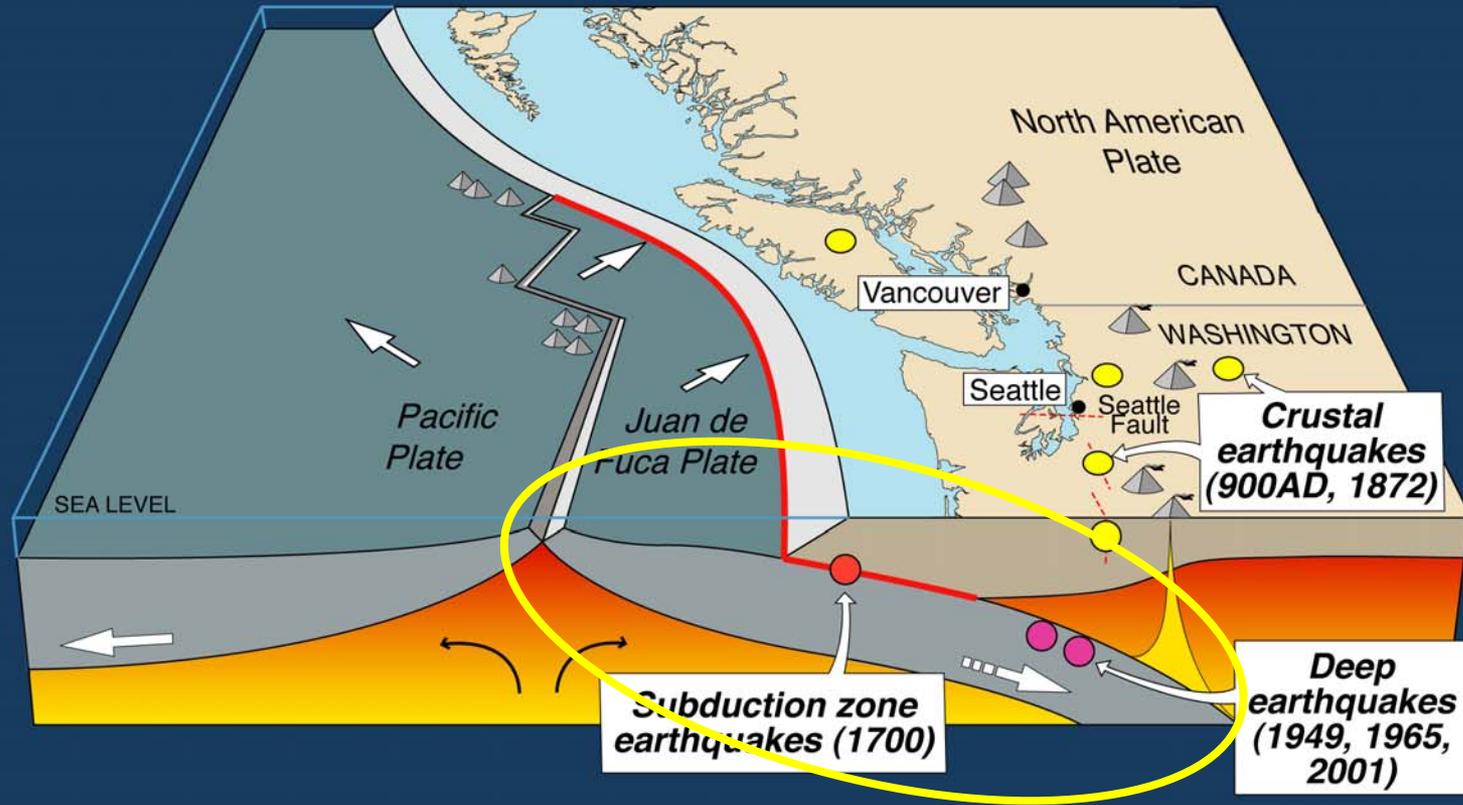


Cascadia earthquake sources



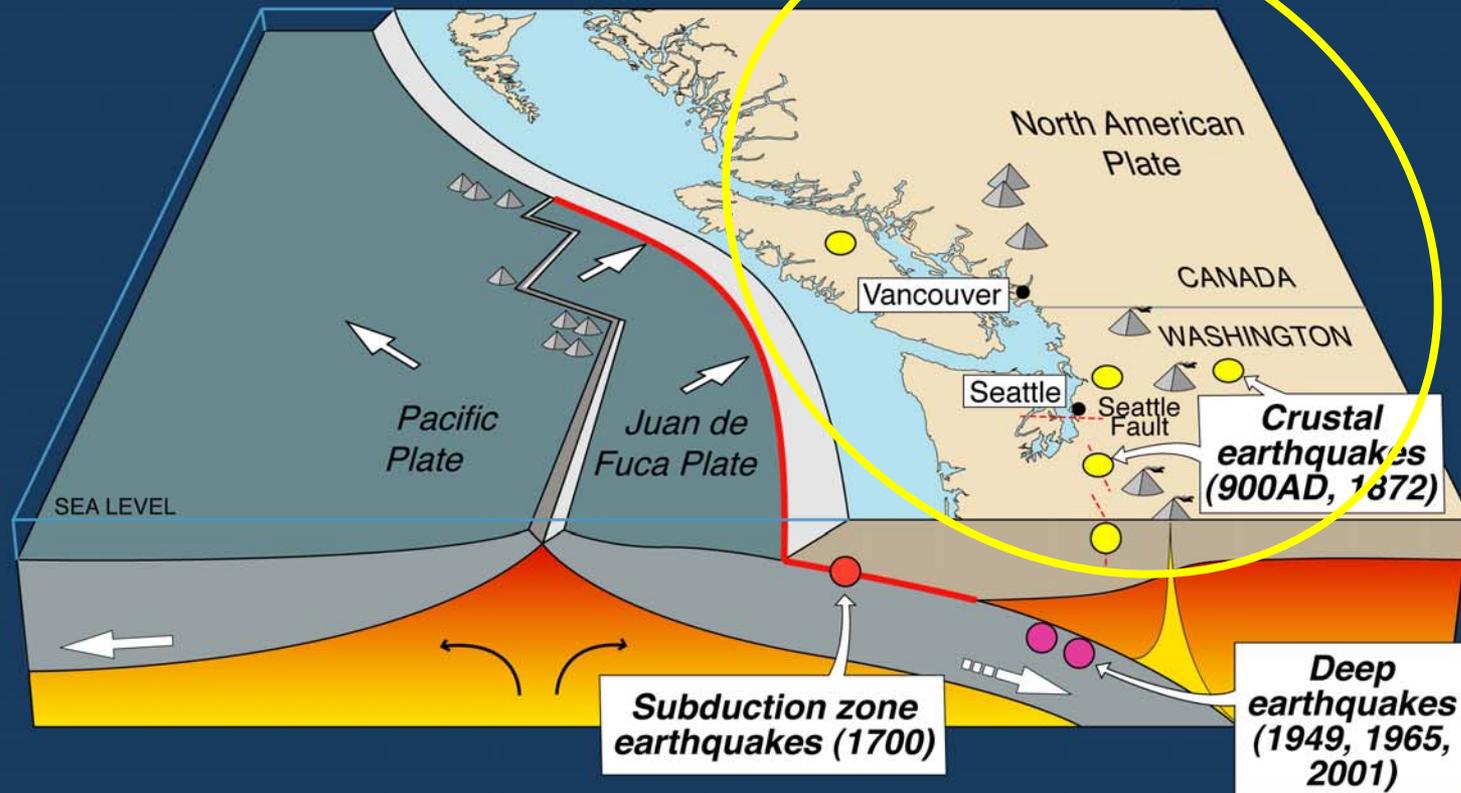
‘Intraplate’ earthquakes tend to be moderate in size & deep, occurring as the plate flexes on its way down.

Cascadia earthquake sources



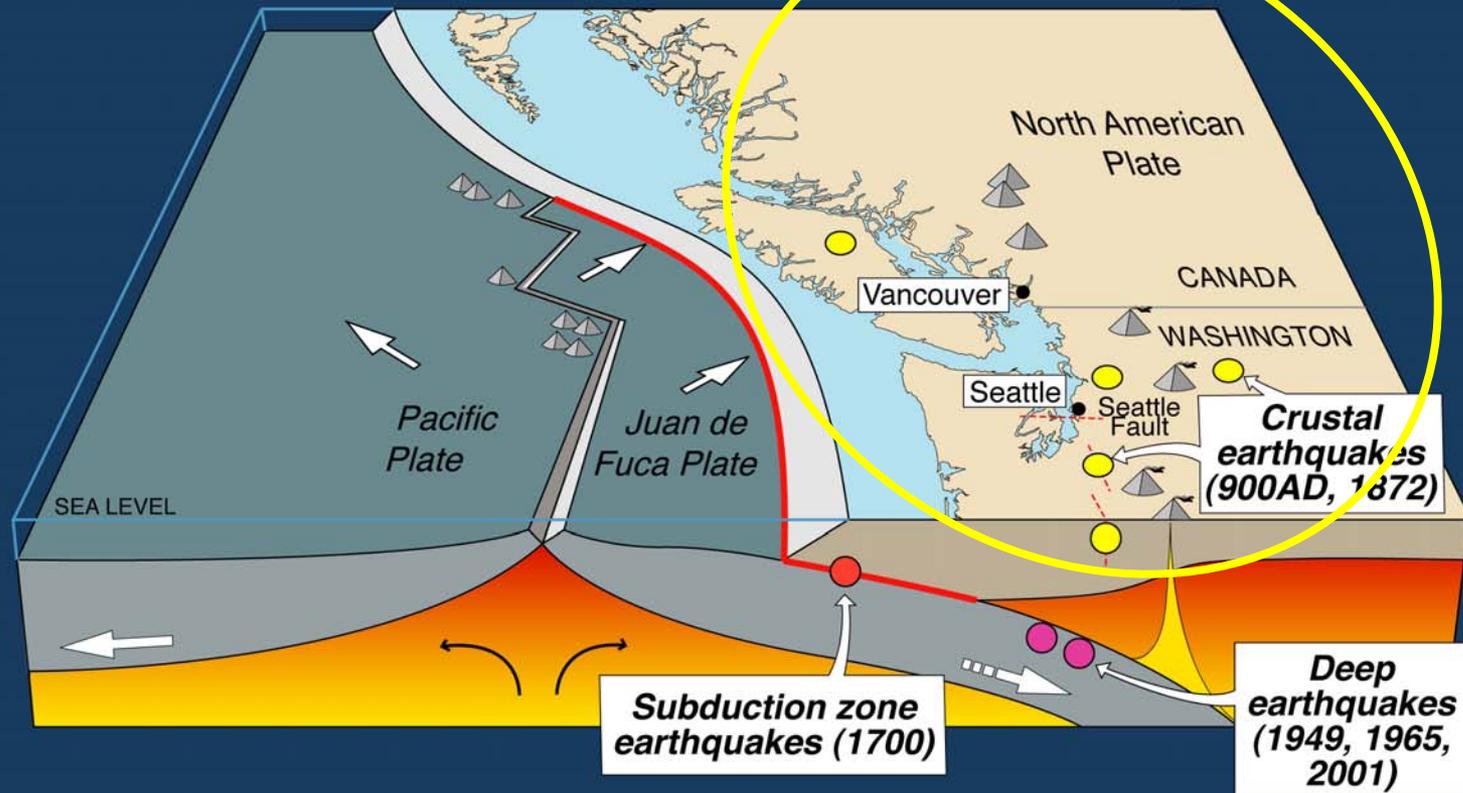
In a 50-year window, there's an 84% chance of a M6.5 intraplate earthquake.

Cascadia earthquake sources

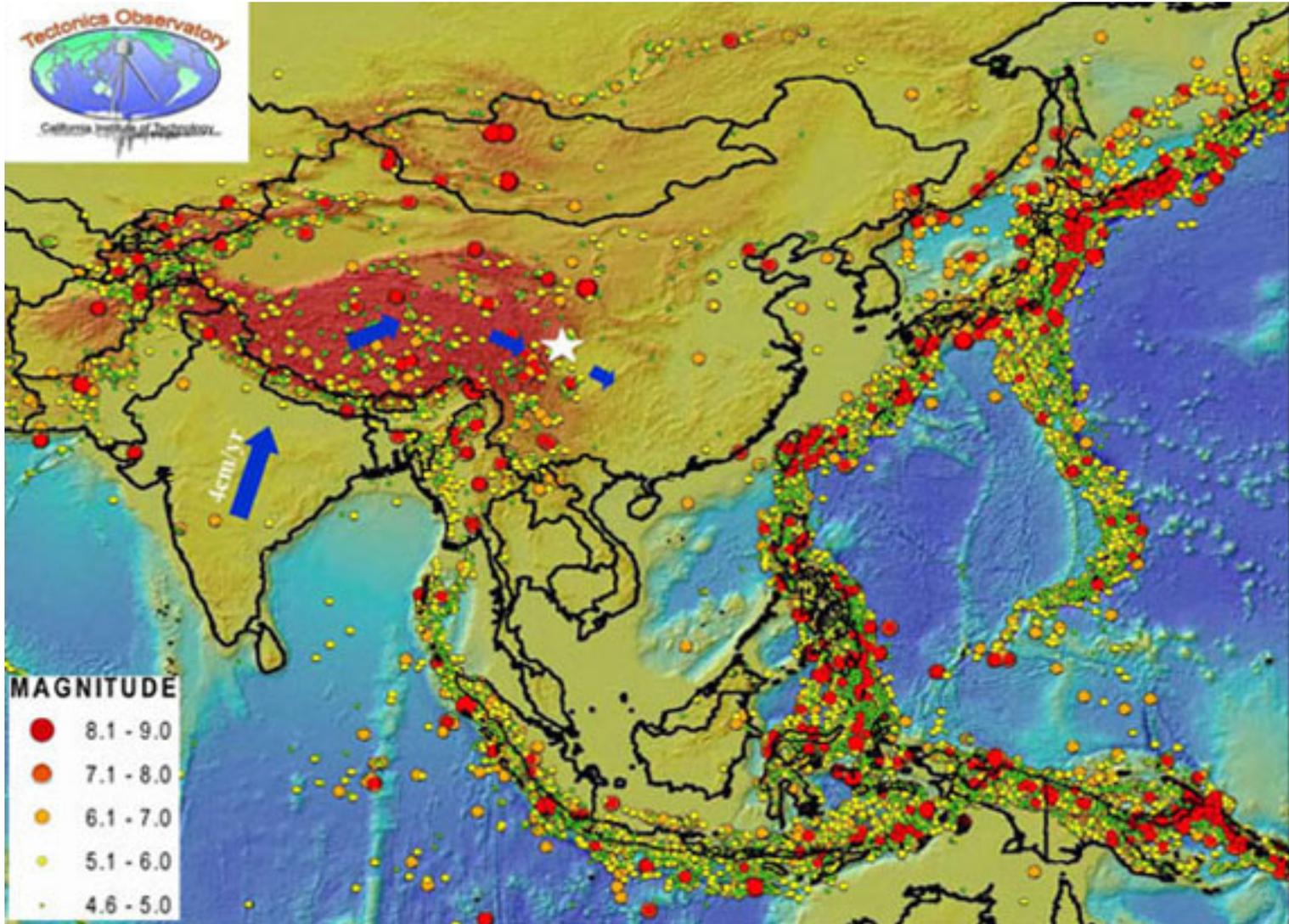


‘Crustal’ earthquakes occur because all the plate motion isn’t taken up along the subduction interface.

Cascadia earthquake sources

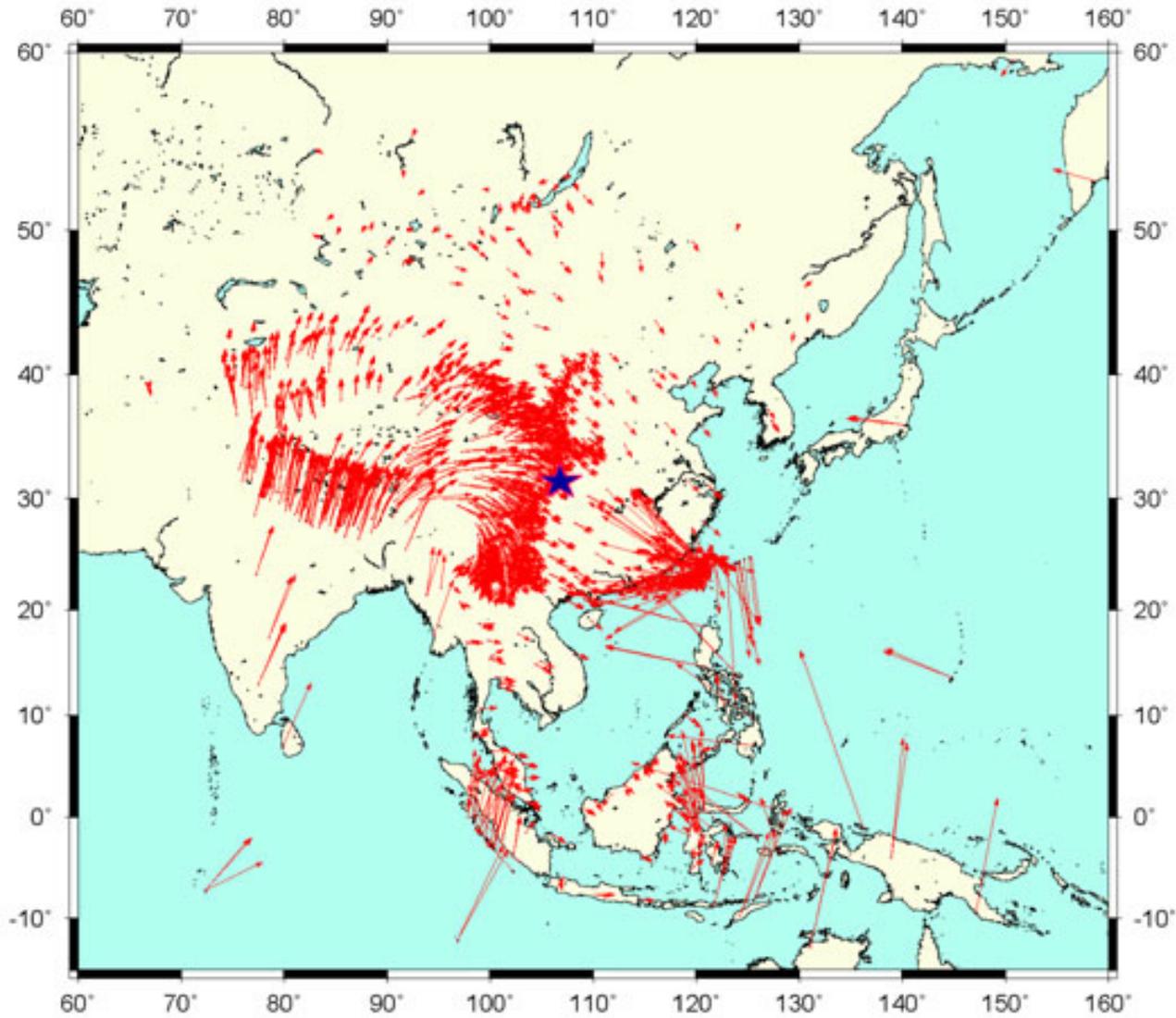


In a 50-year window, the chances are 5% & 15% of an earthquake on the Seattle fault & of a crustal earthquake anywhere in the Puget Sound region, respectively.



The Tibetan plateau is a buttress, pushing into Eurasia.

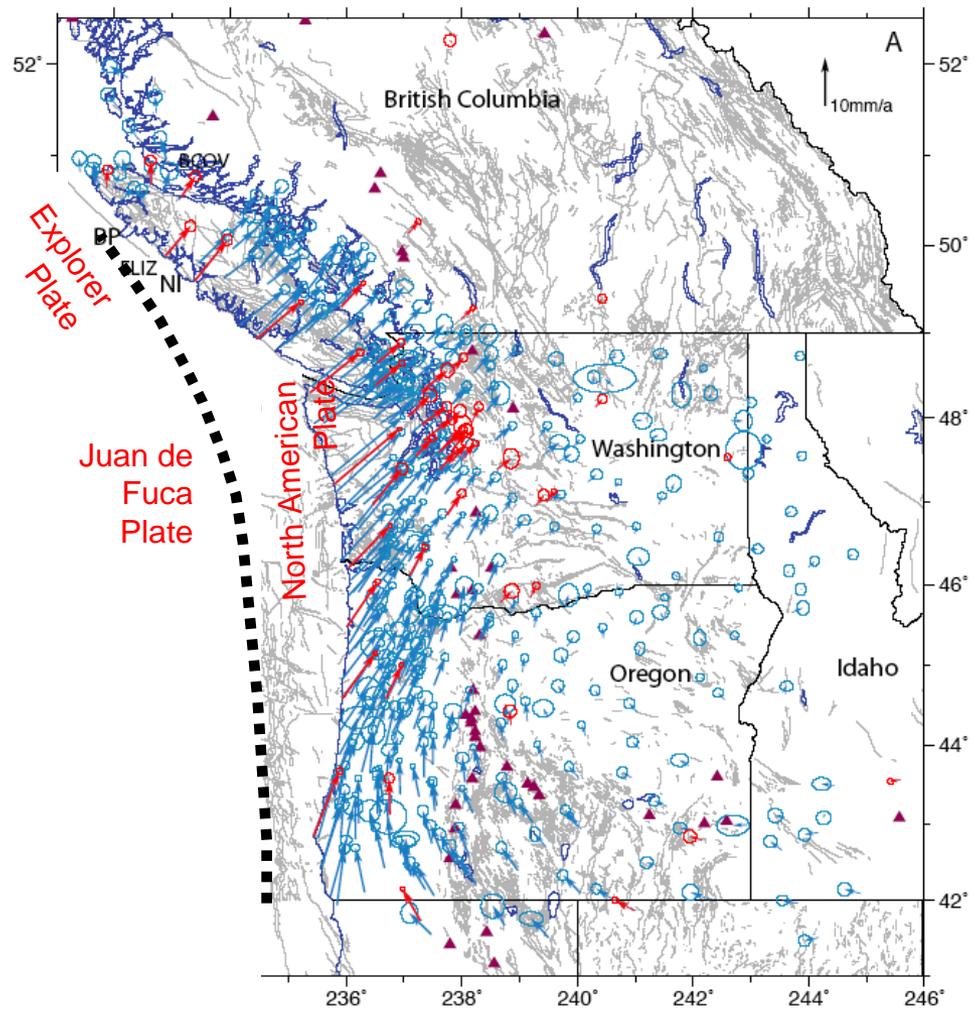
The northward collision of India into Asia is occurring at ~ 4 cm/yr.



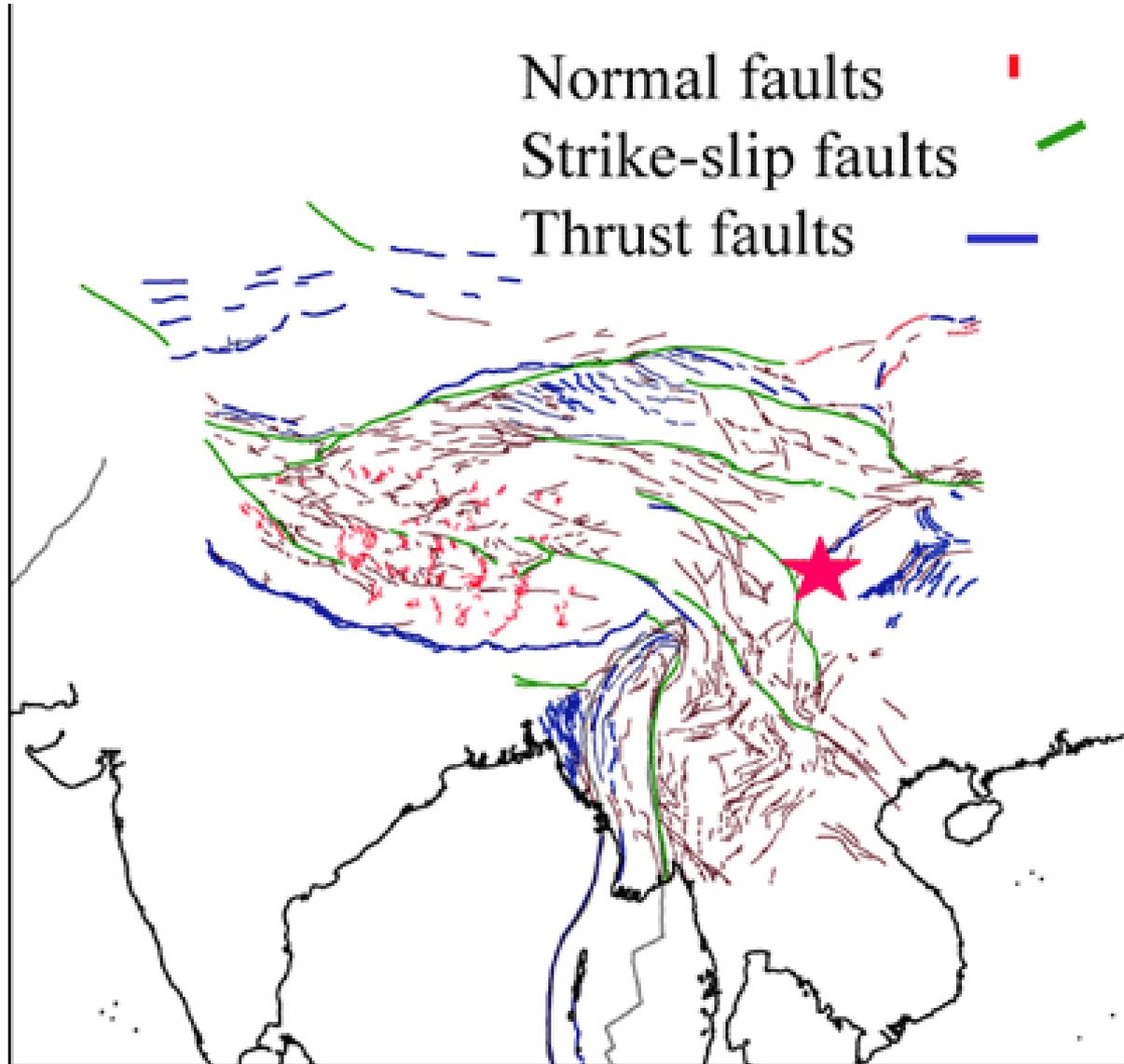
The buttress of Tibet results in eastward displacement at ~ 4 mm/yr. The resulting stresses are released in crustal earthquakes.

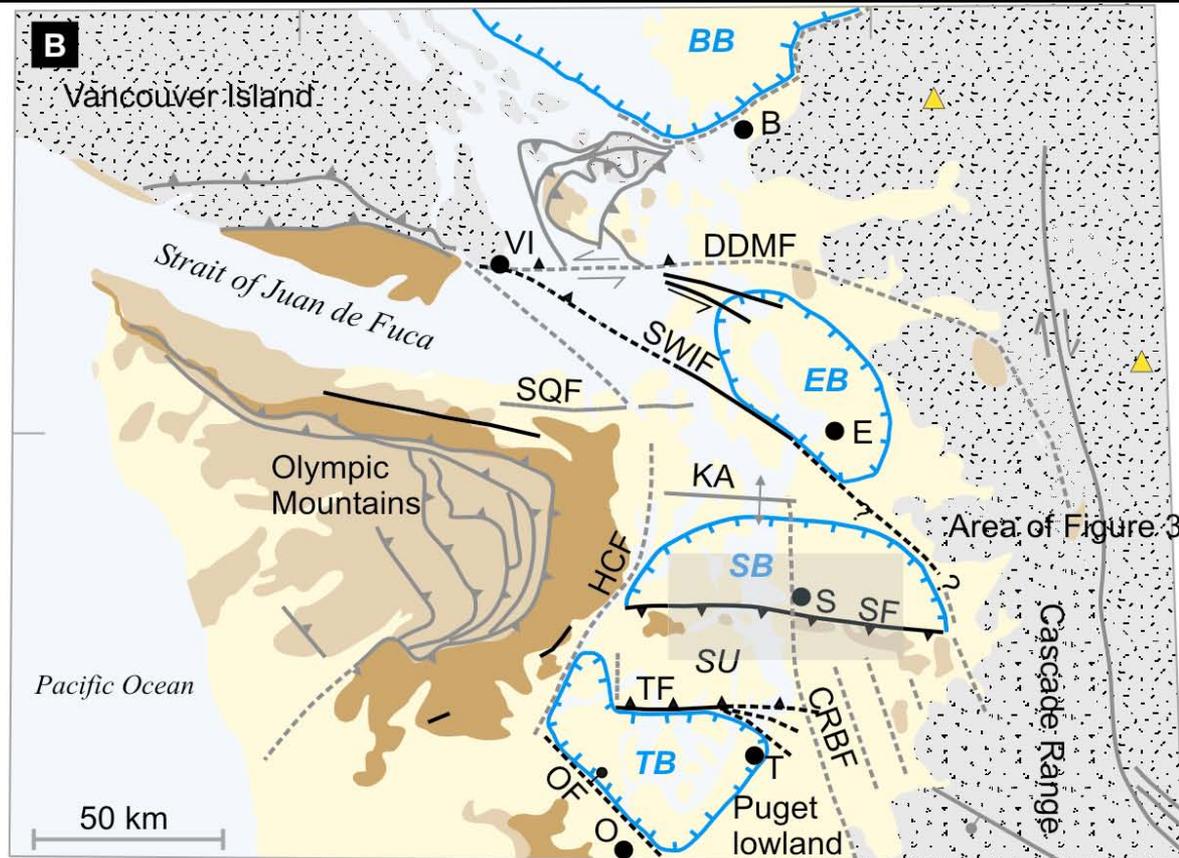
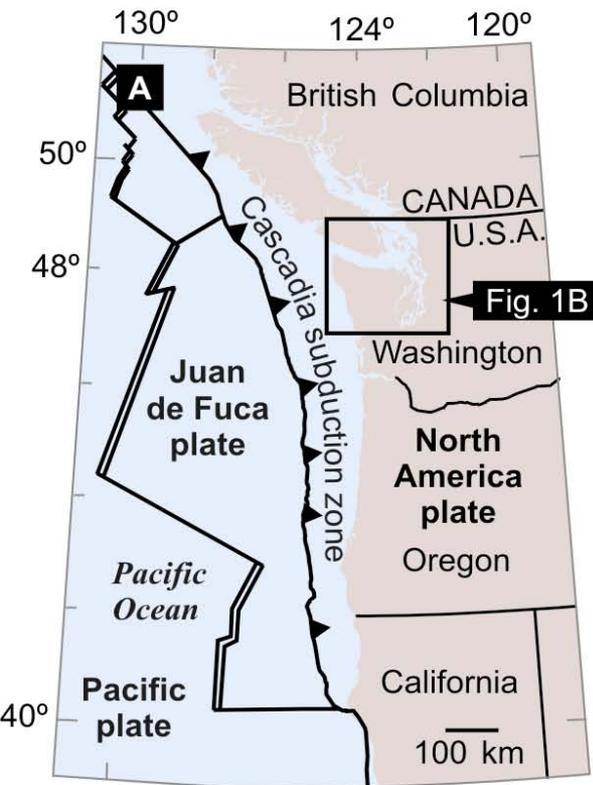
The Juan de Fuca & North American plates also collide at ~ 4 cm/yr.

Stresses build along the stuck part of the plate interface, until it breaks in great earthquakes every 300-500 yrs.



Lots of faults! Individual faults may have long recurrence times, but the collective failure probability is higher, occasionally with dire consequences.

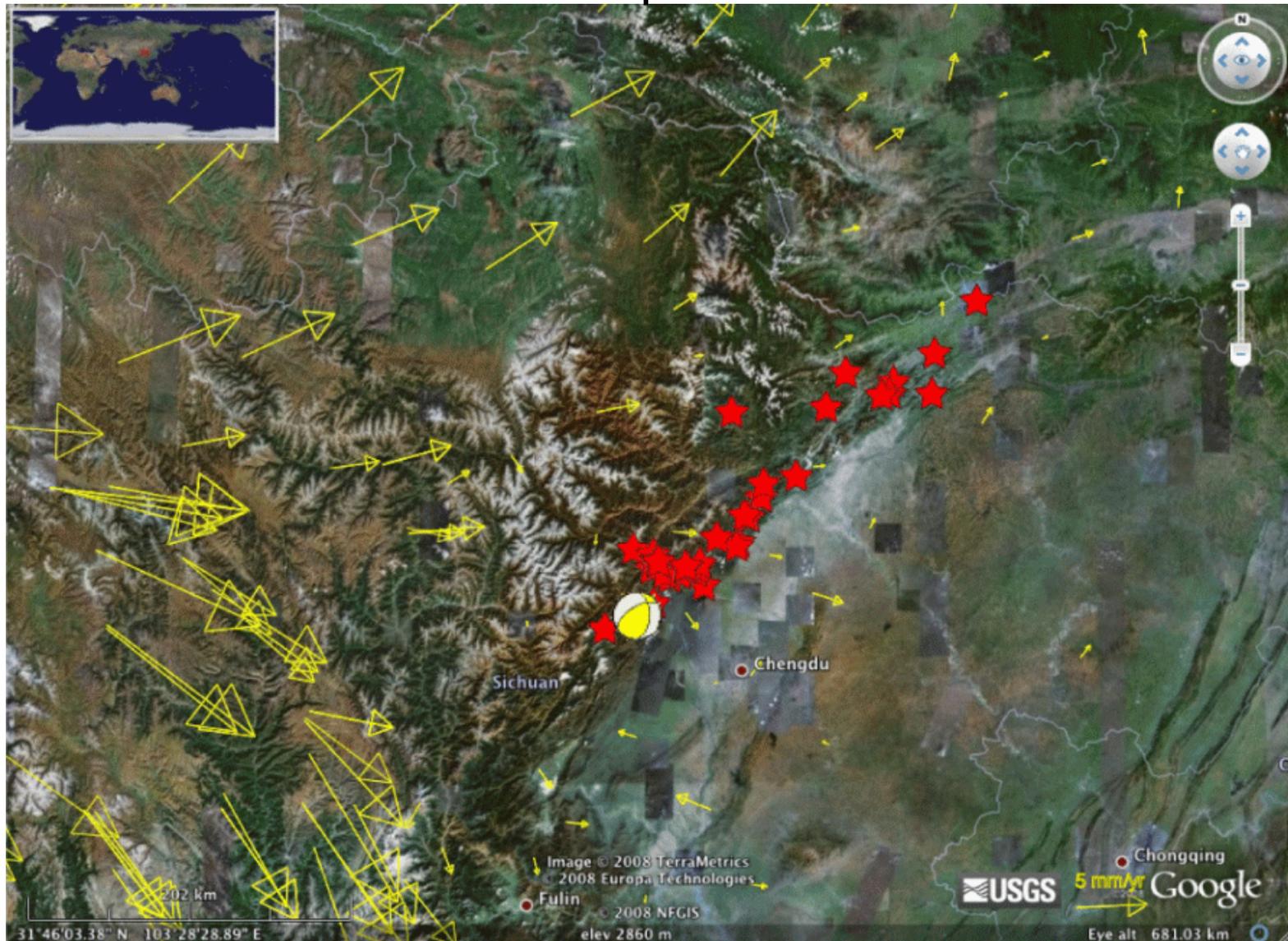




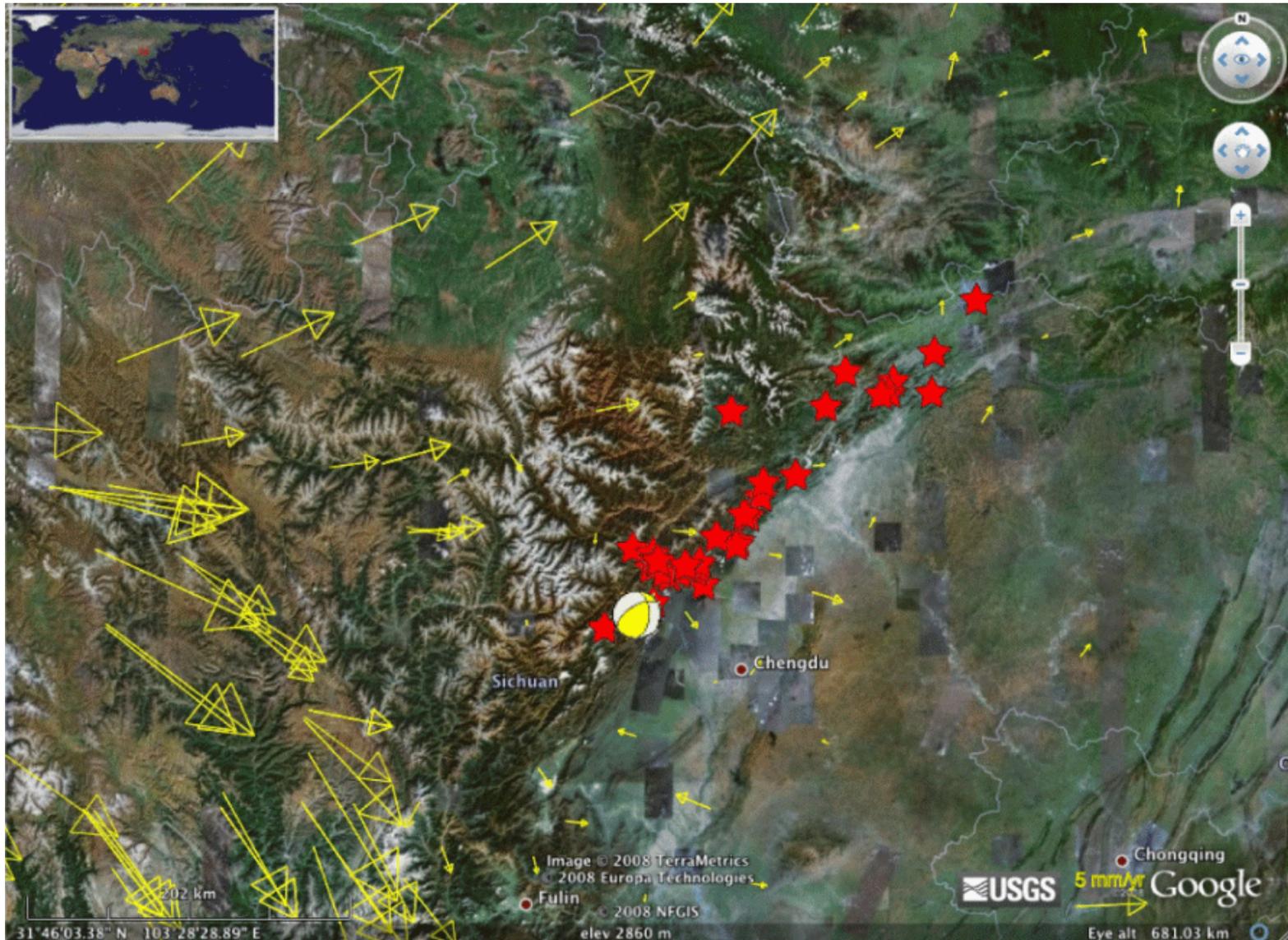
- Structural basin
- Thrust fault (teeth on upthrown block), black where Holocene movement is known or suspected
- Fault, black where Holocene movement is known or suspected
- Fault (bar and ball on downthrown side), black where Holocene movement is known or suspected
- Concealed fault, black where Holocene movement is known or suspected

- Quaternary deposits
- Sedimentary rocks (Paleogene to Neogene)
- Cascade igneous rocks (Oligocene and younger)
- Crescent Formation and other Eocene volcanic rocks
- Basement rocks (pre-Tertiary)
- Quaternary volcano

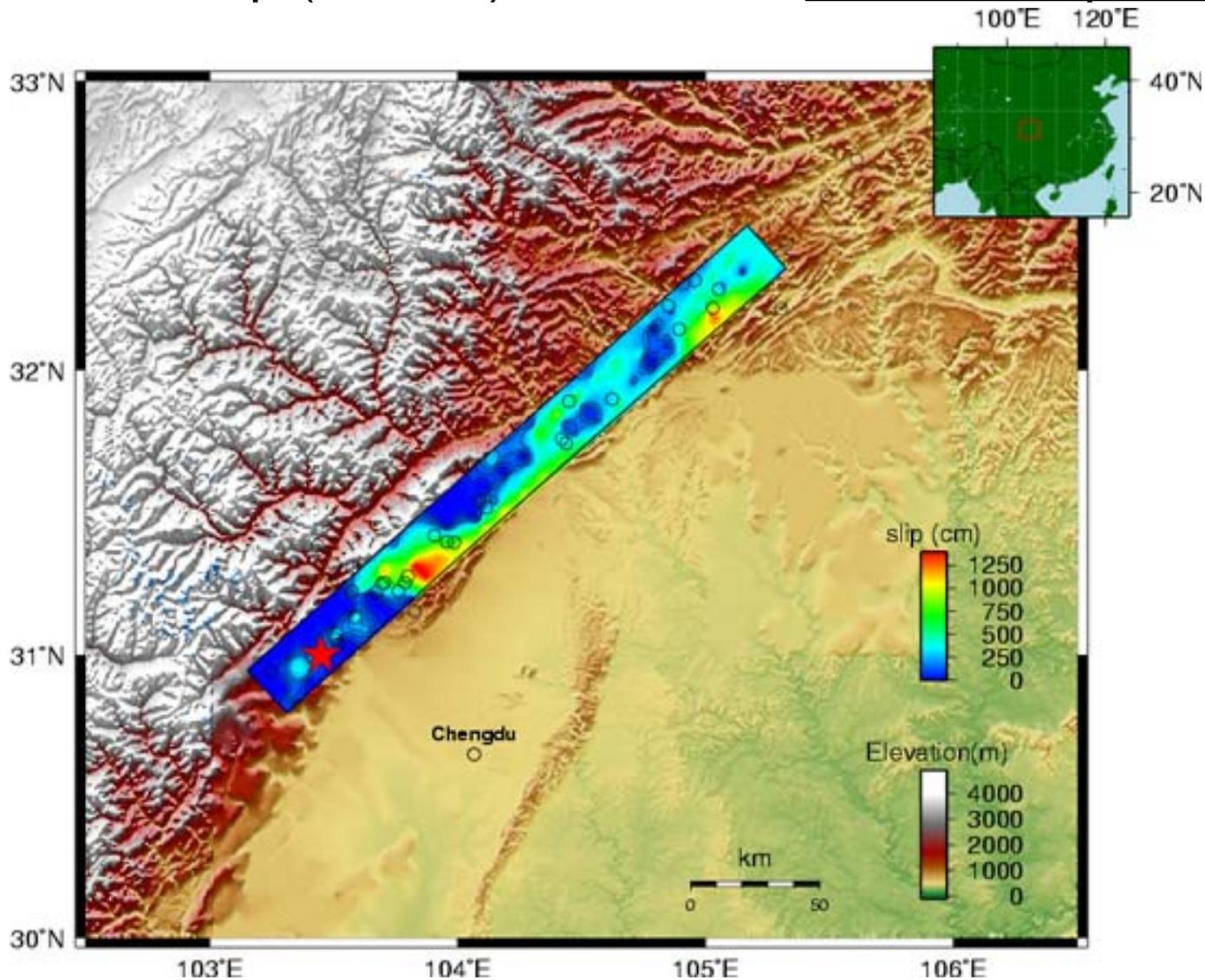
The Wenchuan earthquake broke a fault ~225 km long, bounding a deep basin.



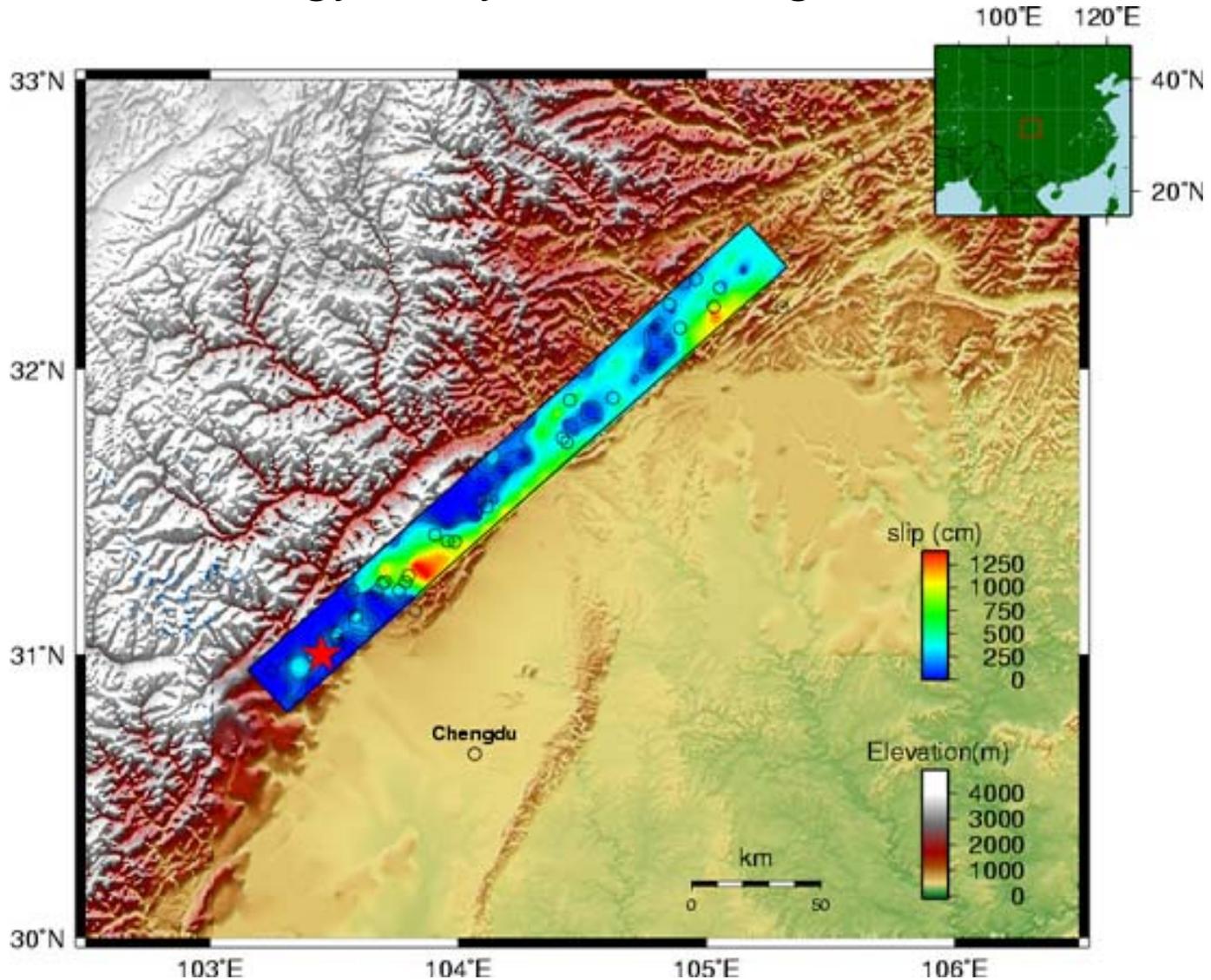
Aftershocks are numerous, large, and will continue for years.



The displacement on the Longmen Shan fault varied greatly. The largest fault slip (8-10 m) was 60 km NE of the epicenter.



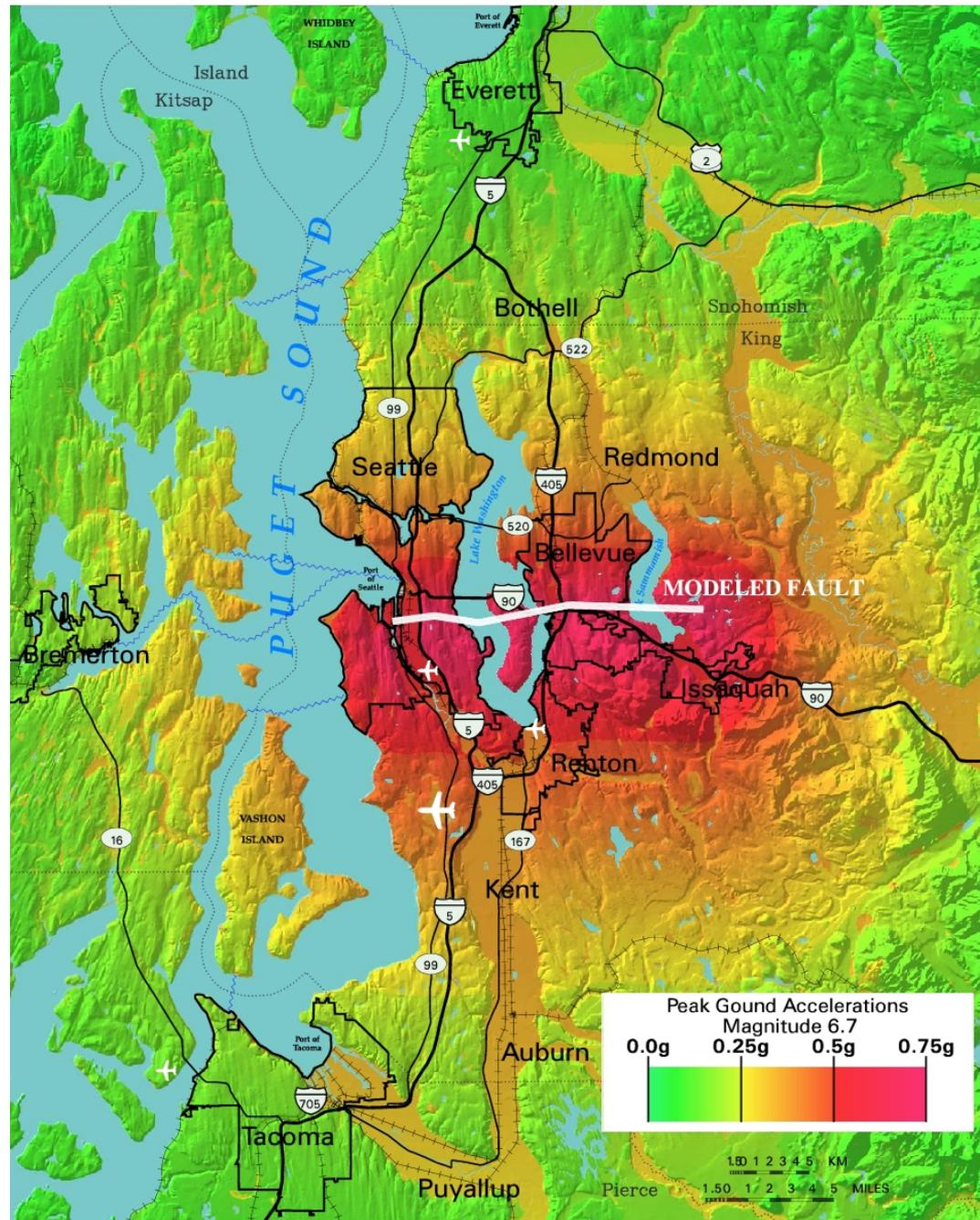
Fortunately the fault break propagated northeastward, focusing energy away from Chengdu.



The epicenter tells us only where the break started.

The *mapped* Seattle fault is a LOT shorter and the likely magnitude MUCH smaller (~M7).

The South Whidbey Island fault may be significantly longer.



Ground truth.



Seattle Fault

uplifted
prehistoric
beach

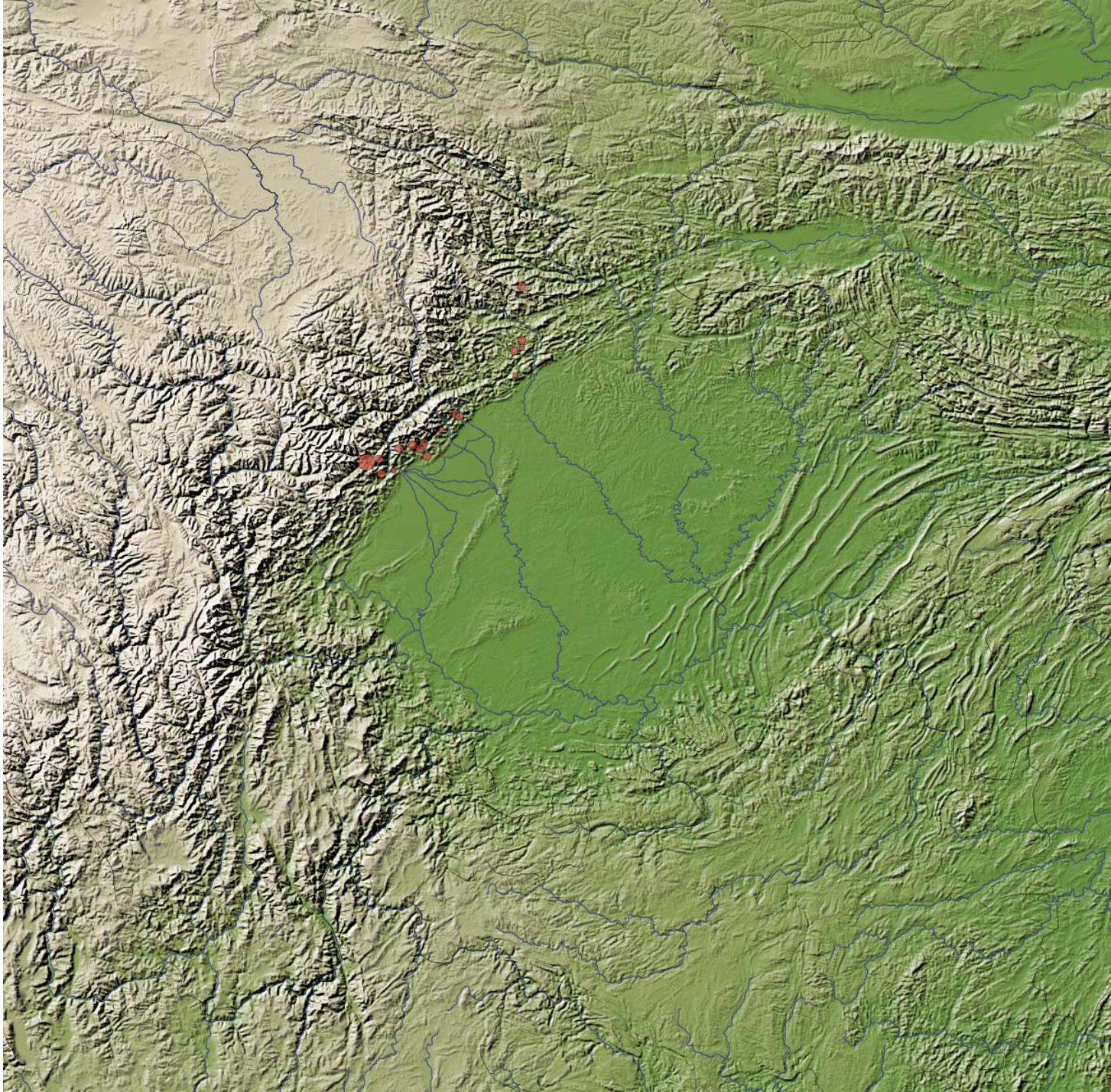
Ground truth.



Paleo-earthquakes.



The Chinese landscape



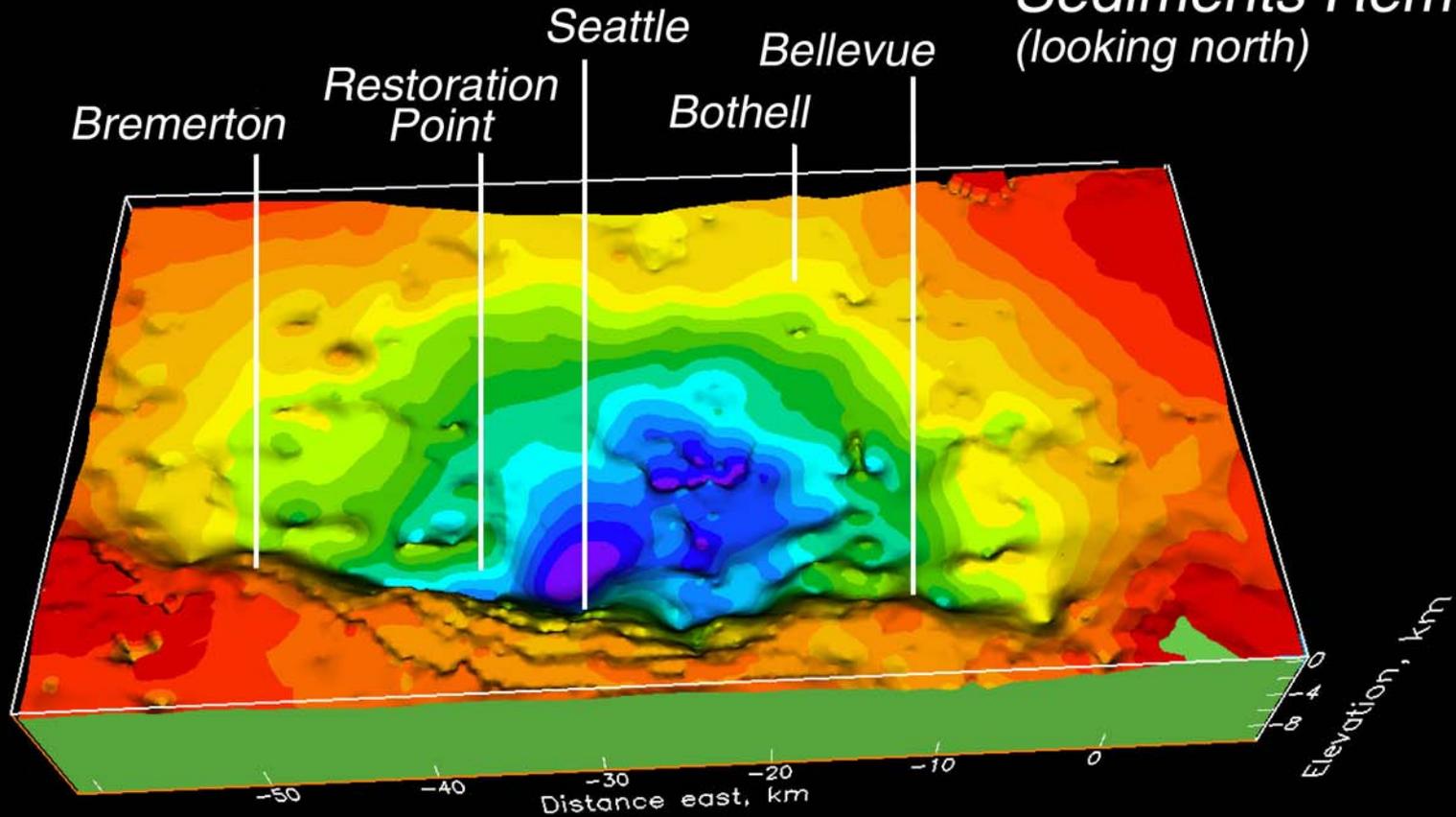
The Pacific Northwest landscape



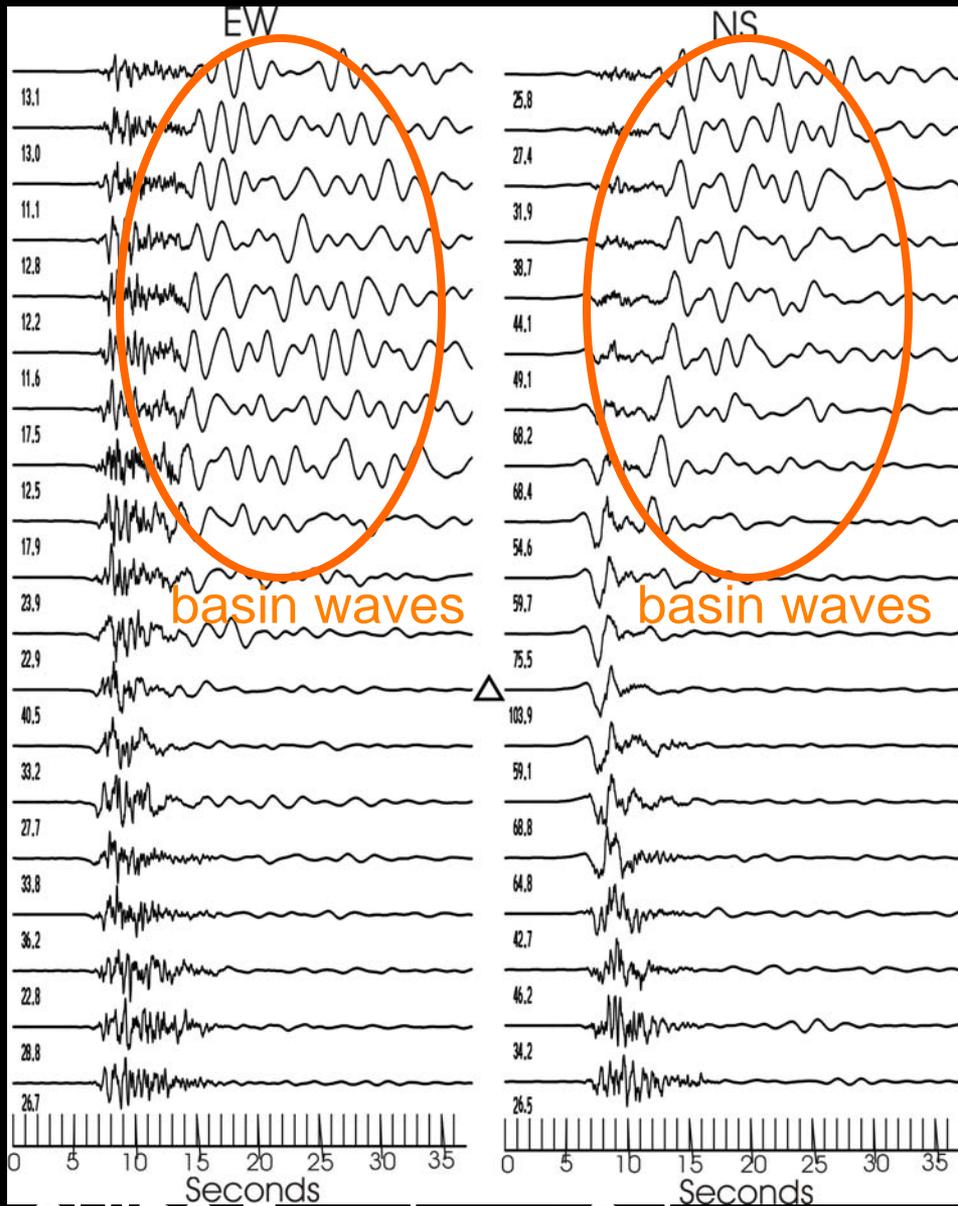
Seattle

Local Geologic Structure is Important.

Seattle Basin with
Sediments Removed
(looking north)



No vertical exaggeration
Color contour interval 0.5 km



SHIPS Experiment Seismograms

Horizontal shaking from explosions recorded along a north-south line traversing the Seattle Basin, where sediments amplify and extend the shaking.

High-resolution surficial/shallow geologic data; the GeoMap Project

<http://geomapnw.ess.washington.edu>



The Pacific Northwest Center for Geologic Mapping Studies

SEARCH

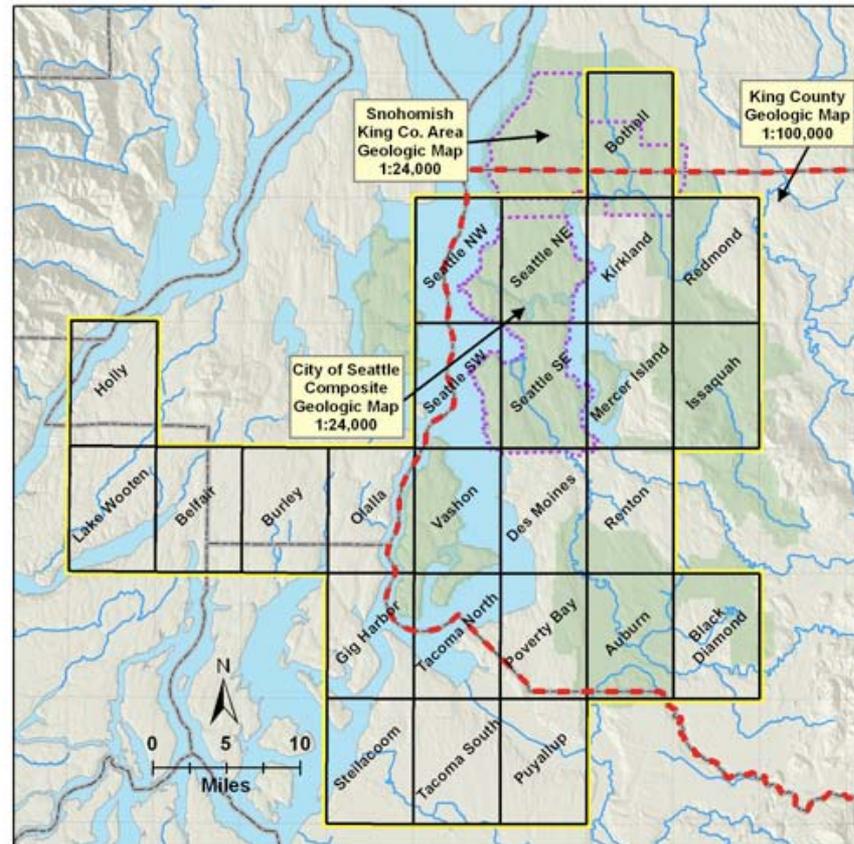
CONTACT US

EVENTS

SITE MAP

GEOLOGIC MAPS

Postscript or pdf versions of our maps can be downloaded by clicking on the appropriate selection in the image below. All map areas displayed inside the yellow boundary are either in preparation or review and will be posted on the website as soon as they are available.



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- [3-D Maps & Models](#)
- [Data Collection](#)
- [Database Development](#)

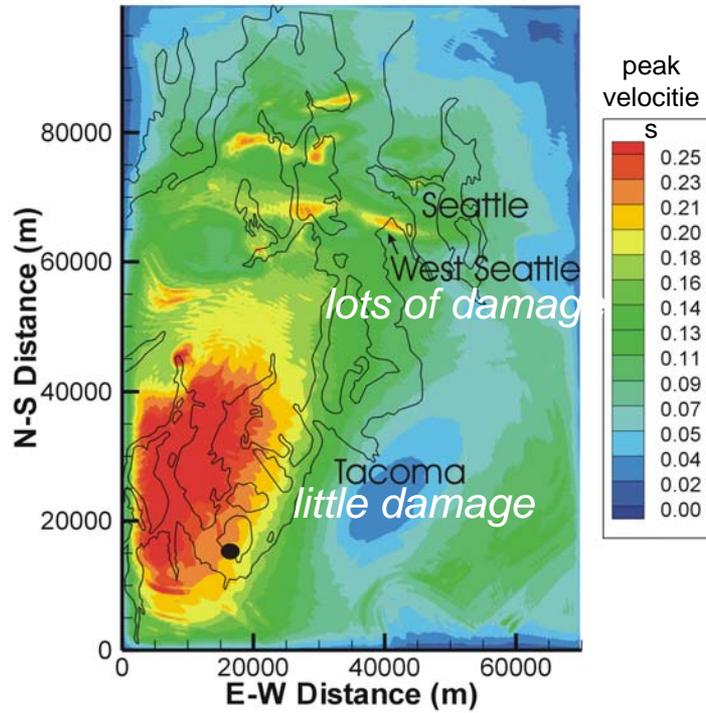
Who We Are

- [About the Center](#)
- [Faculty and Staff](#)
- [Project Partners](#)
- [Job Opportunities](#)

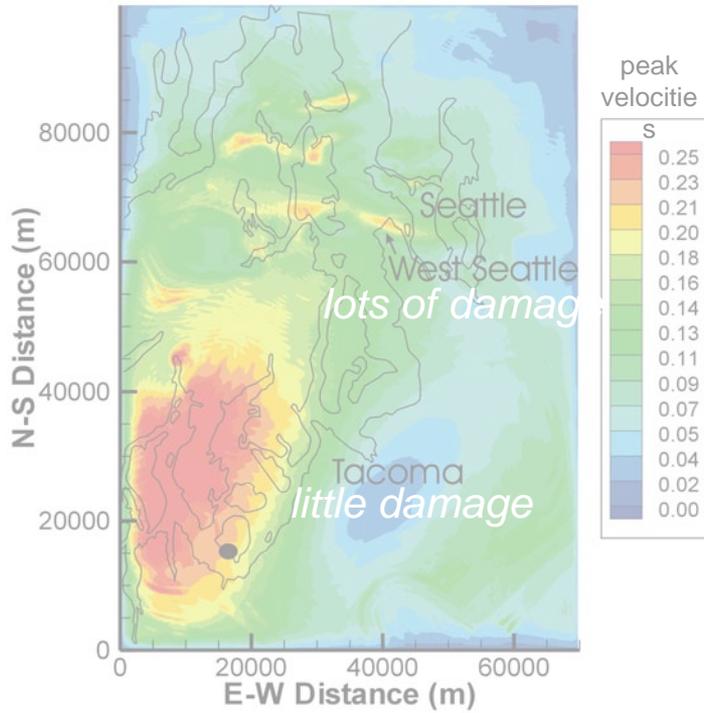
POPULAR DOWNLOADS



3D Simulation of the 2001 Nisqually Earthquake Shaking

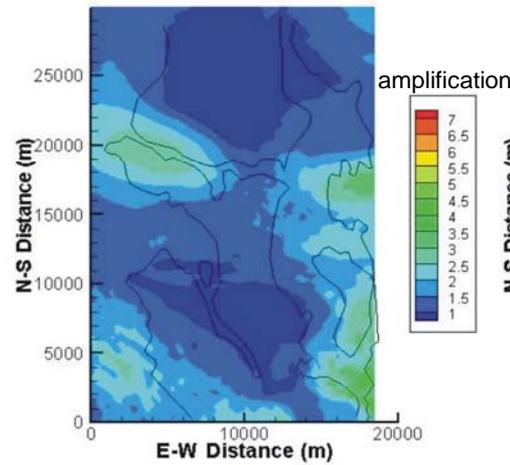


3D Simulation of the 2001 Nisqually Earthquake Shaking

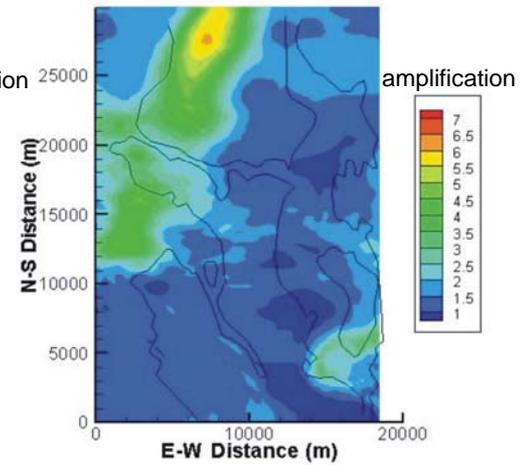


Lots of Simulations -> Earthquakes south of Seattle amplify more!

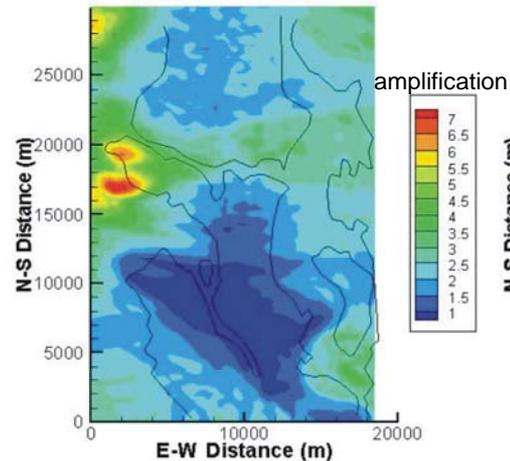
From North



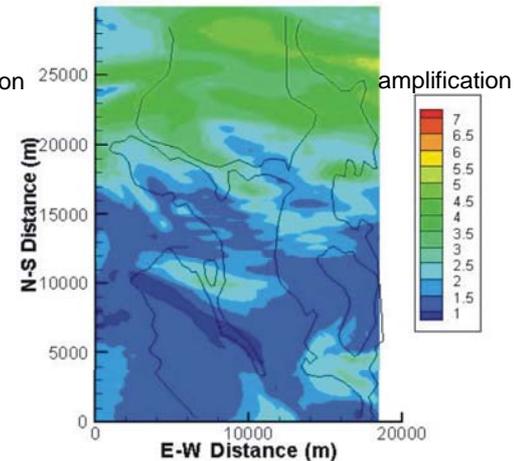
From East



From South

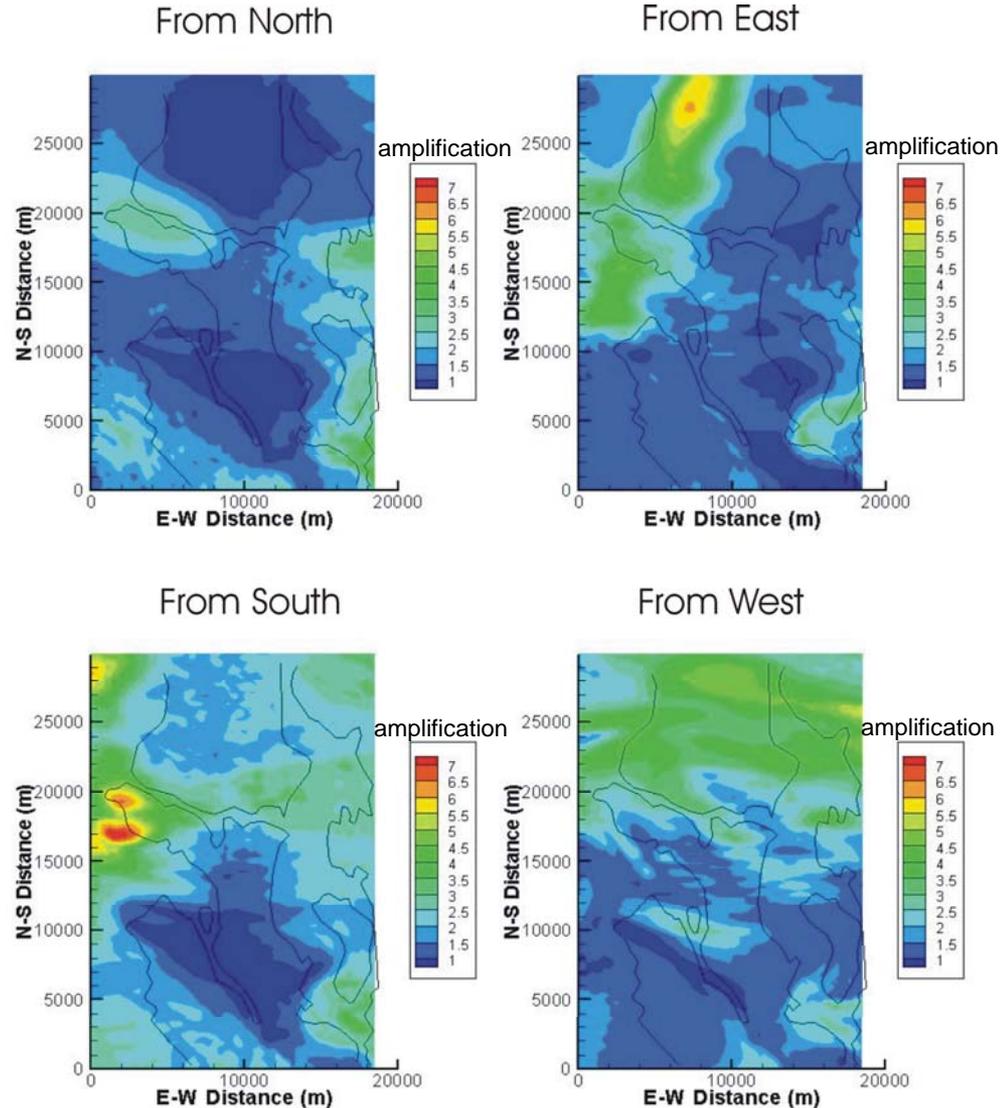
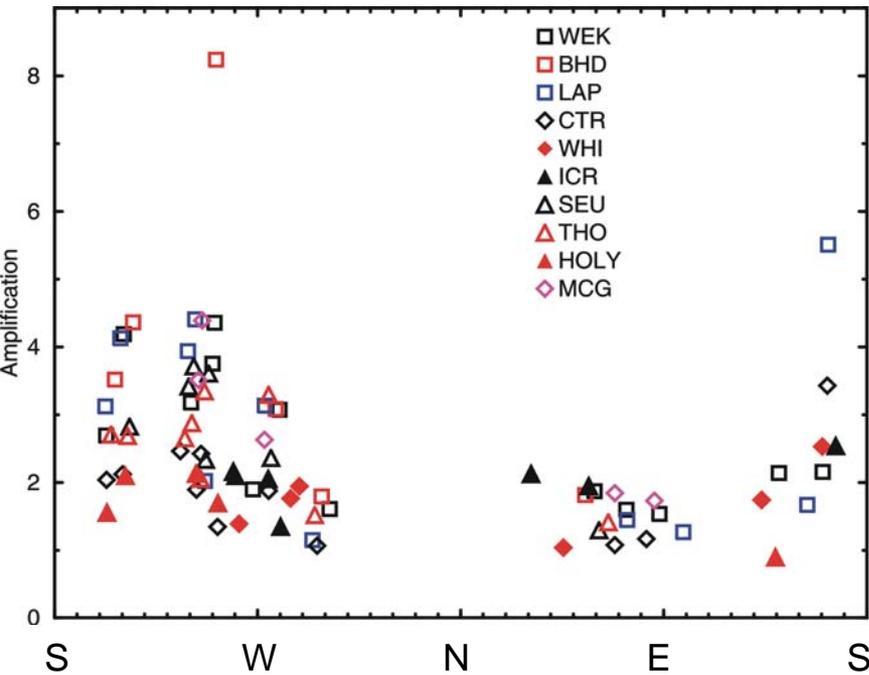


From West

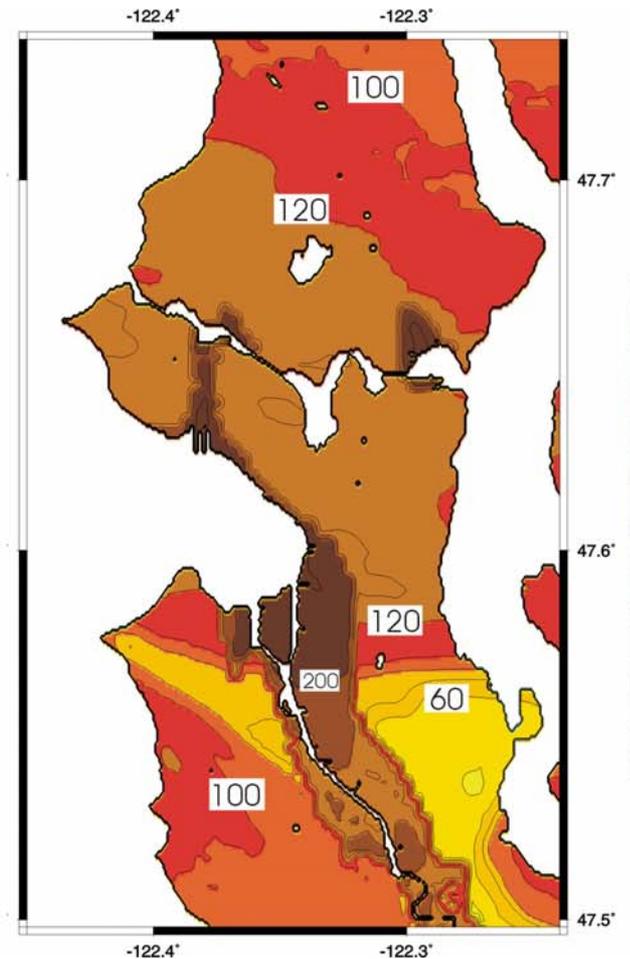
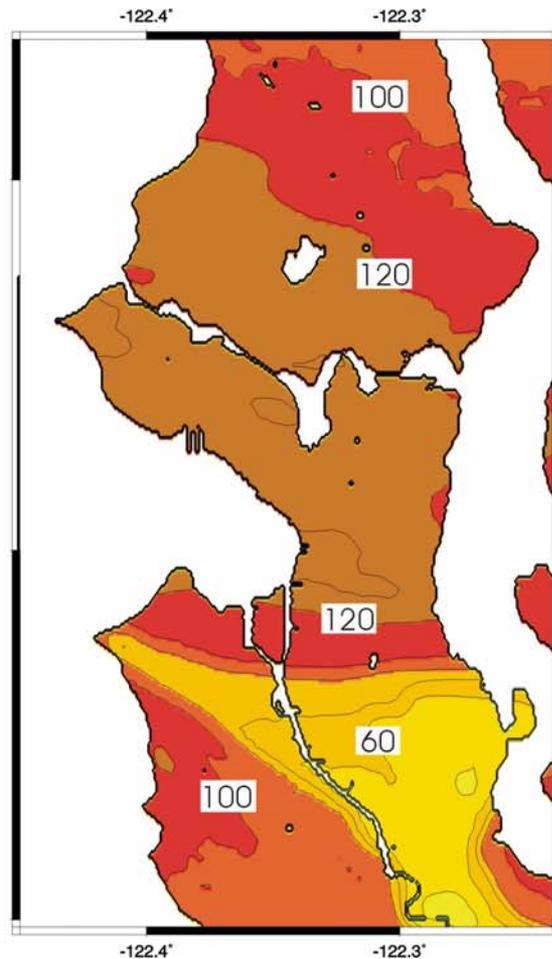
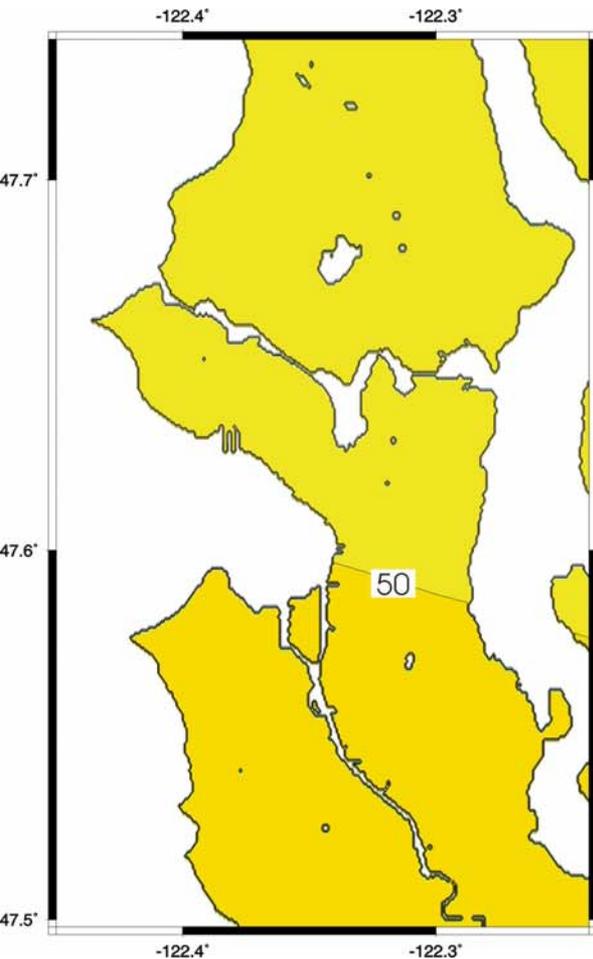


We 'ground truth'
these with real
measurements.

Lots of Simulations ->
Earthquakes south of
Seattle amplify more!



1 Hz Spectral Acceleration (%g) with 2% chance of being exceeded in 50 years



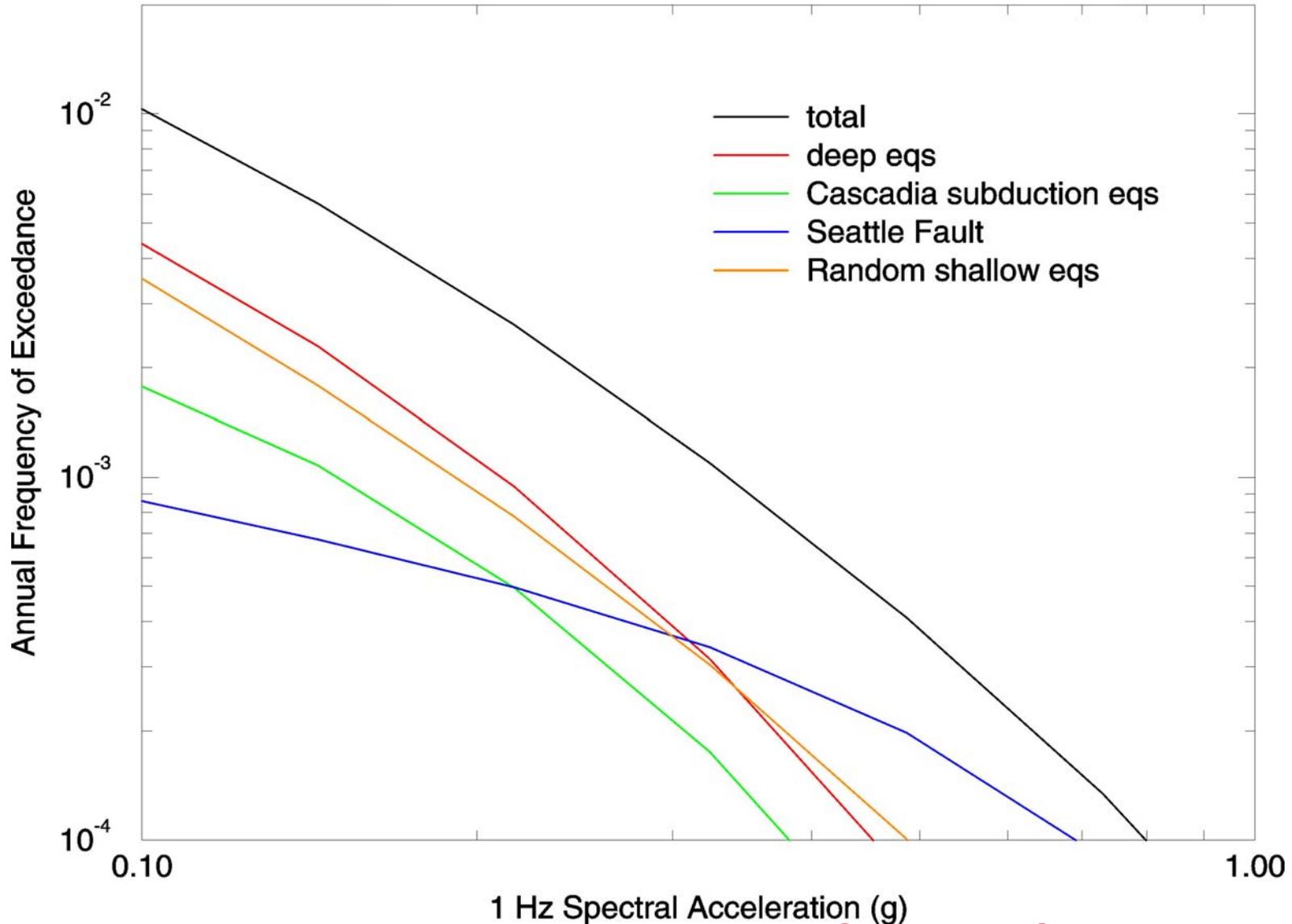
one of 2002 national
seismic hazard maps;
rock site condition

Using 3D simulations
with basin effects
and directivity

Using 3D simulations
and nonlinear
ampl. for fill/alluvium

Downtown Seattle

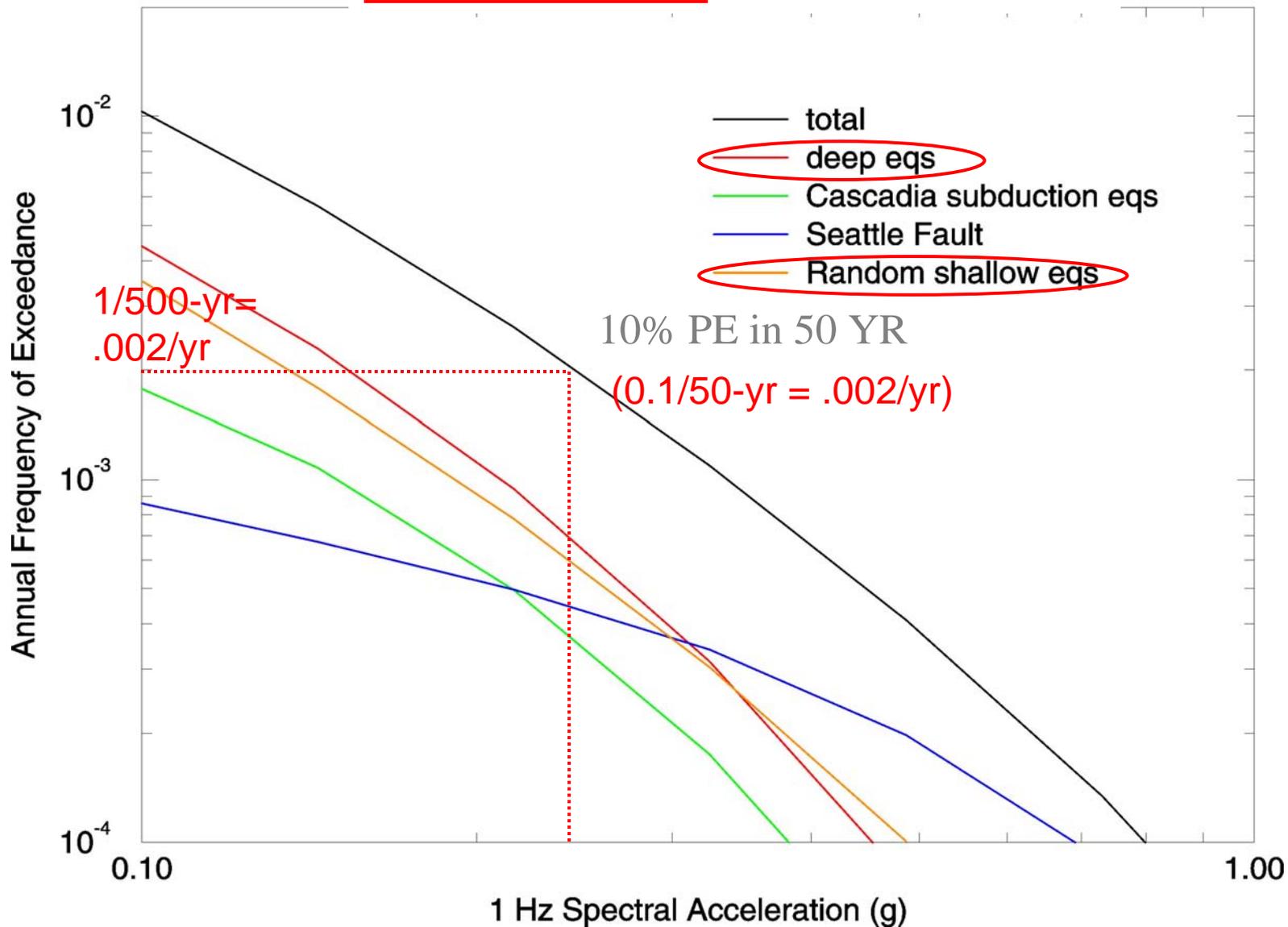
Ground Motion Hazard Curves



These describe the likelihood of SHAKING, not a particular earthquake!

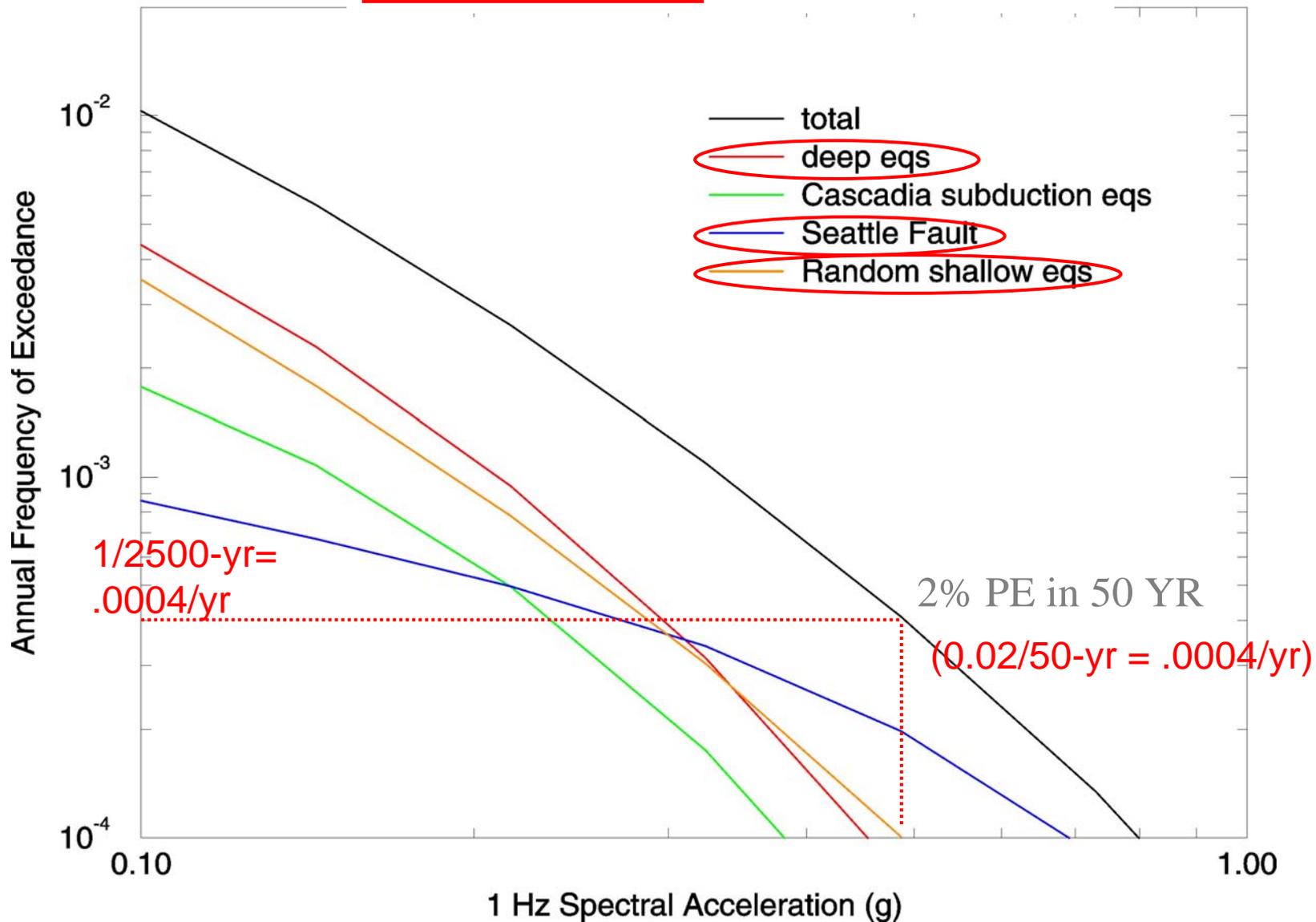
Downtown Seattle

Ground Motion Hazard Curves



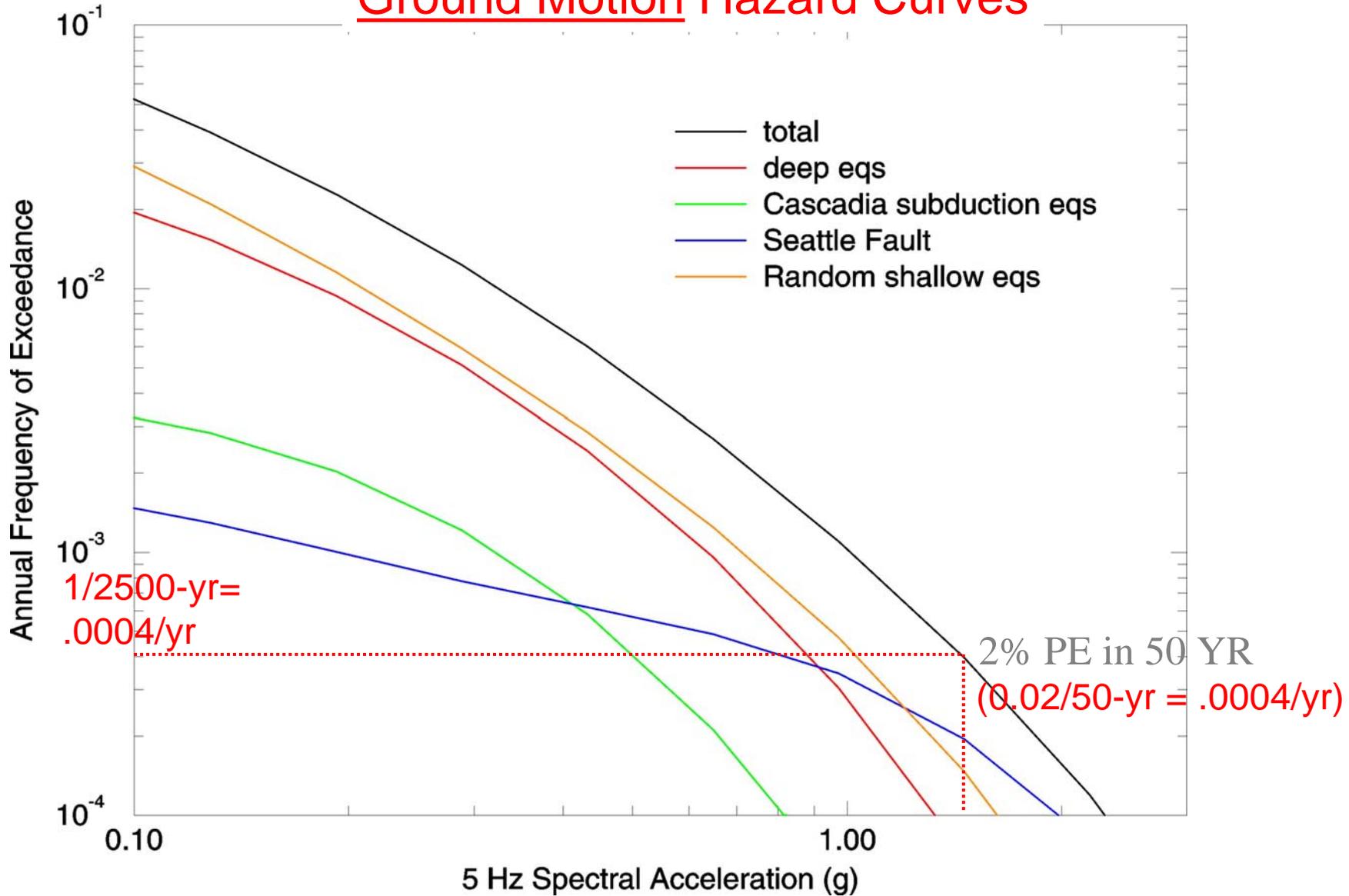
Downtown Seattle

Ground Motion Hazard Curves

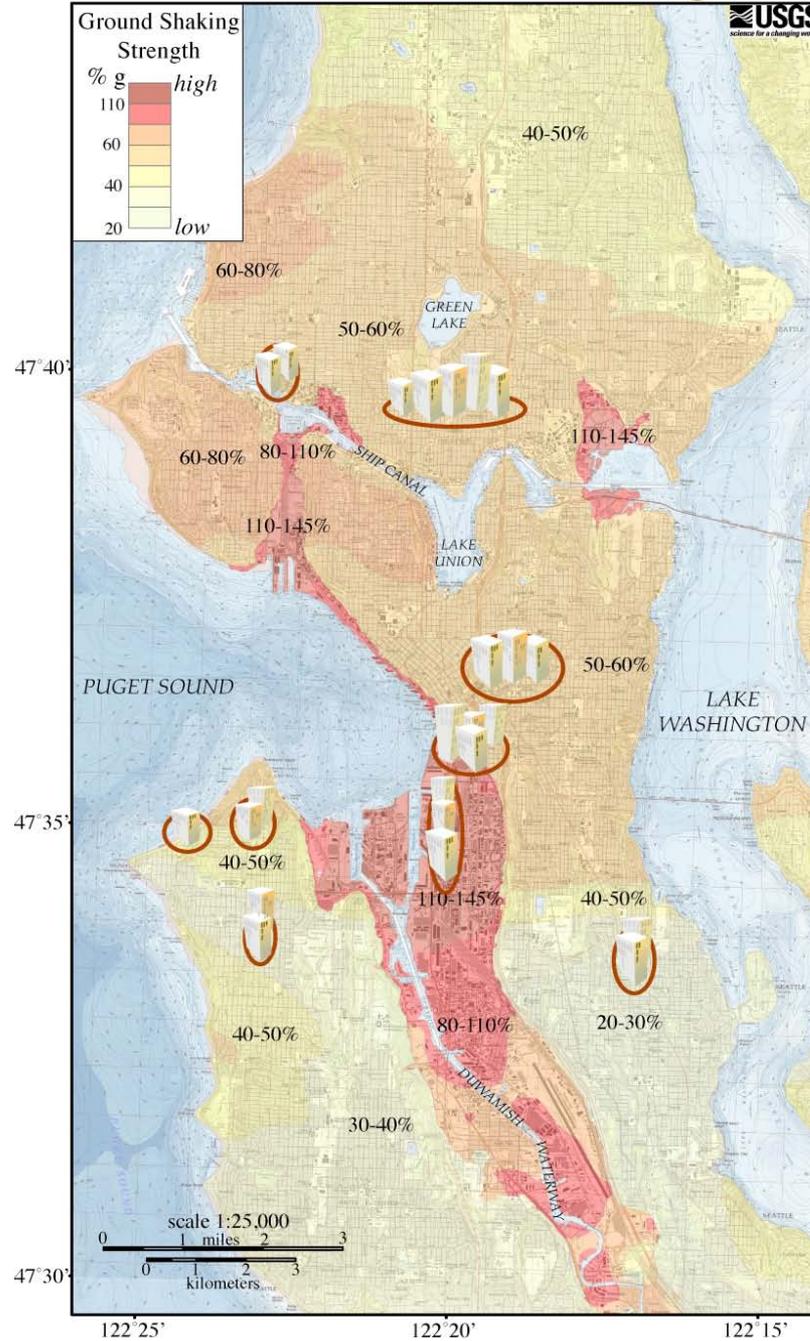


Downtown Seattle

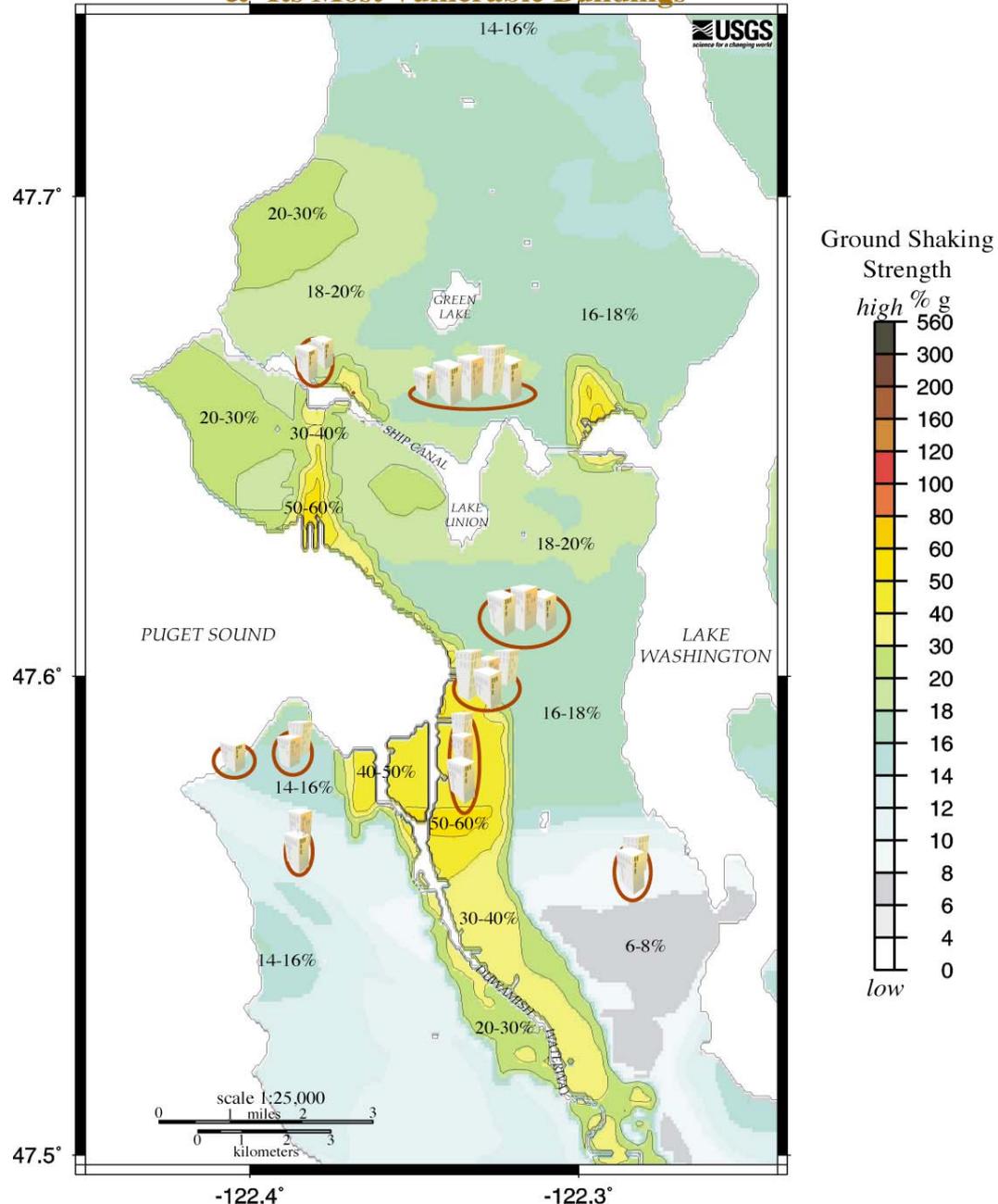
Ground Motion Hazard Curves



Seattle Earthquake Hazard (10% probability in 50 yrs) & Its Most Vulnerable Buildings



Seattle Earthquake Hazard (50% probability in 50 yrs) & Its Most Vulnerable Buildings



Thank You!

Questions?

<http://earthquake.usgs.gov/regional/pacnw>

<http://www.pnsn.org>