

Seattle Earthquake Hazards

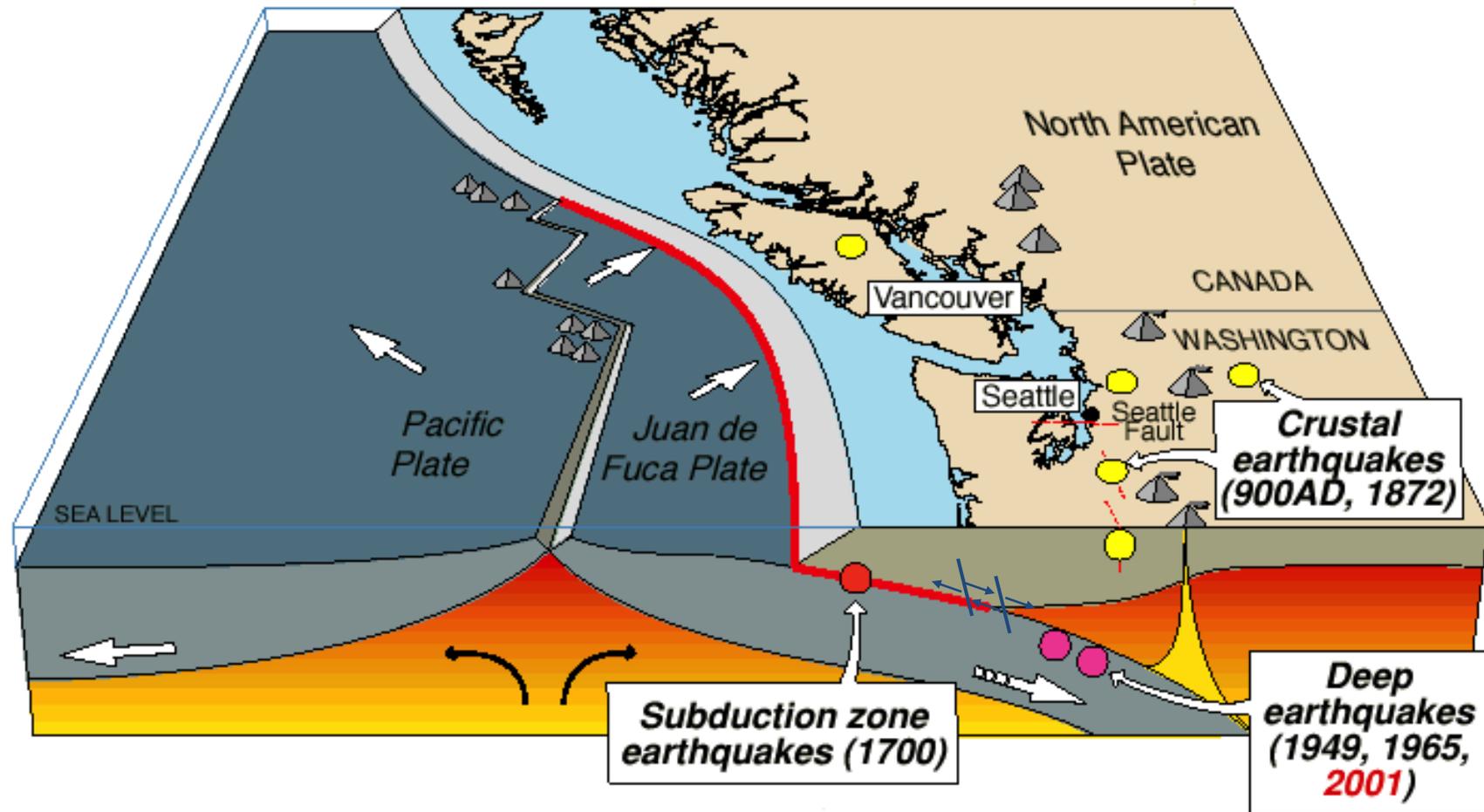
Learning from global tragedies

Seattle City Hall
June 21st 2011

Bill Steele, Director of Information Services
University of Washington
Pacific Northwest Seismic Network
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Pacific Northwest Seismicity

Puget Sound Area Earthquake Sources



PNSN Stations

- ~750



Channels



Broadband



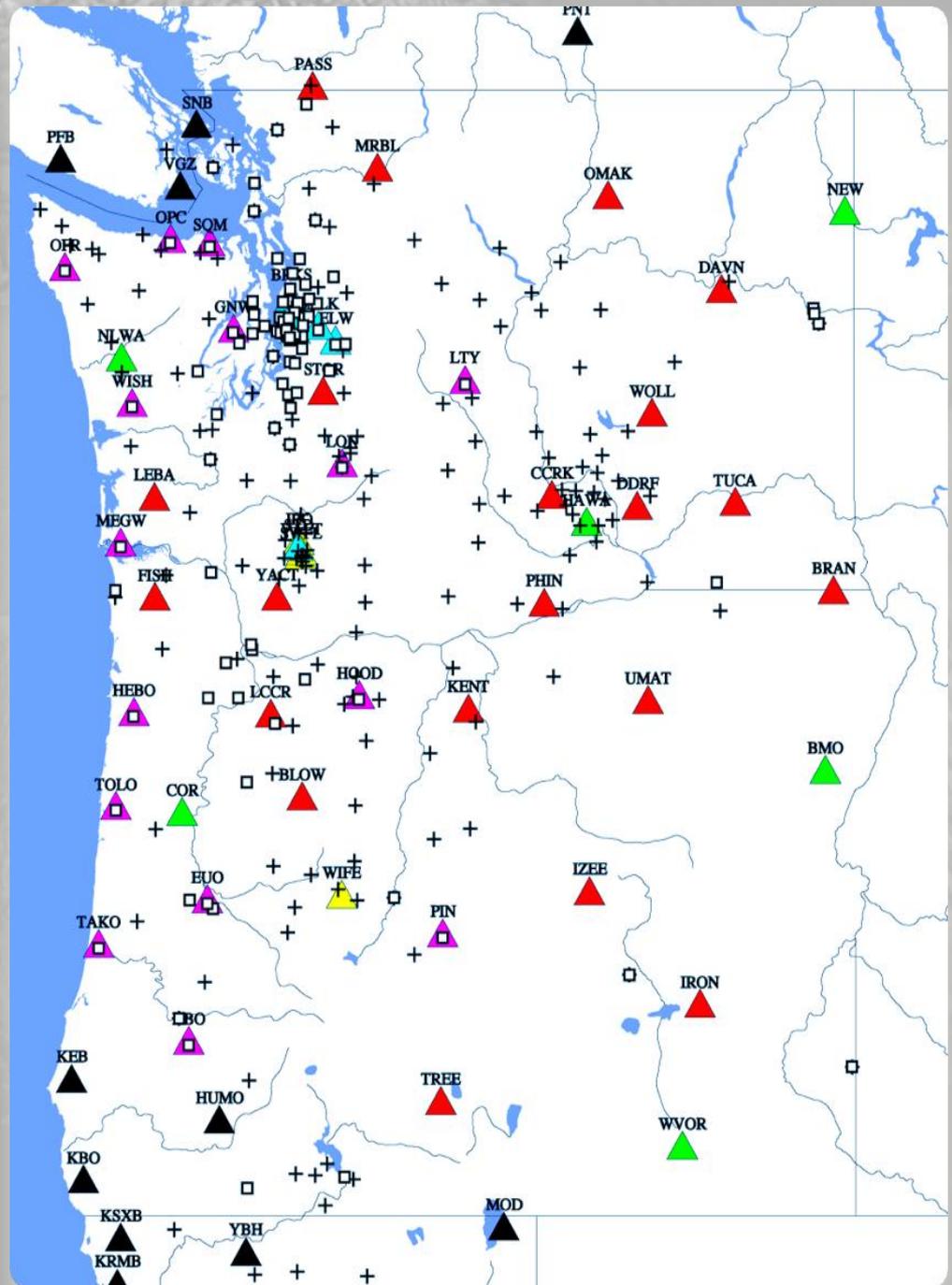
Strong Motion

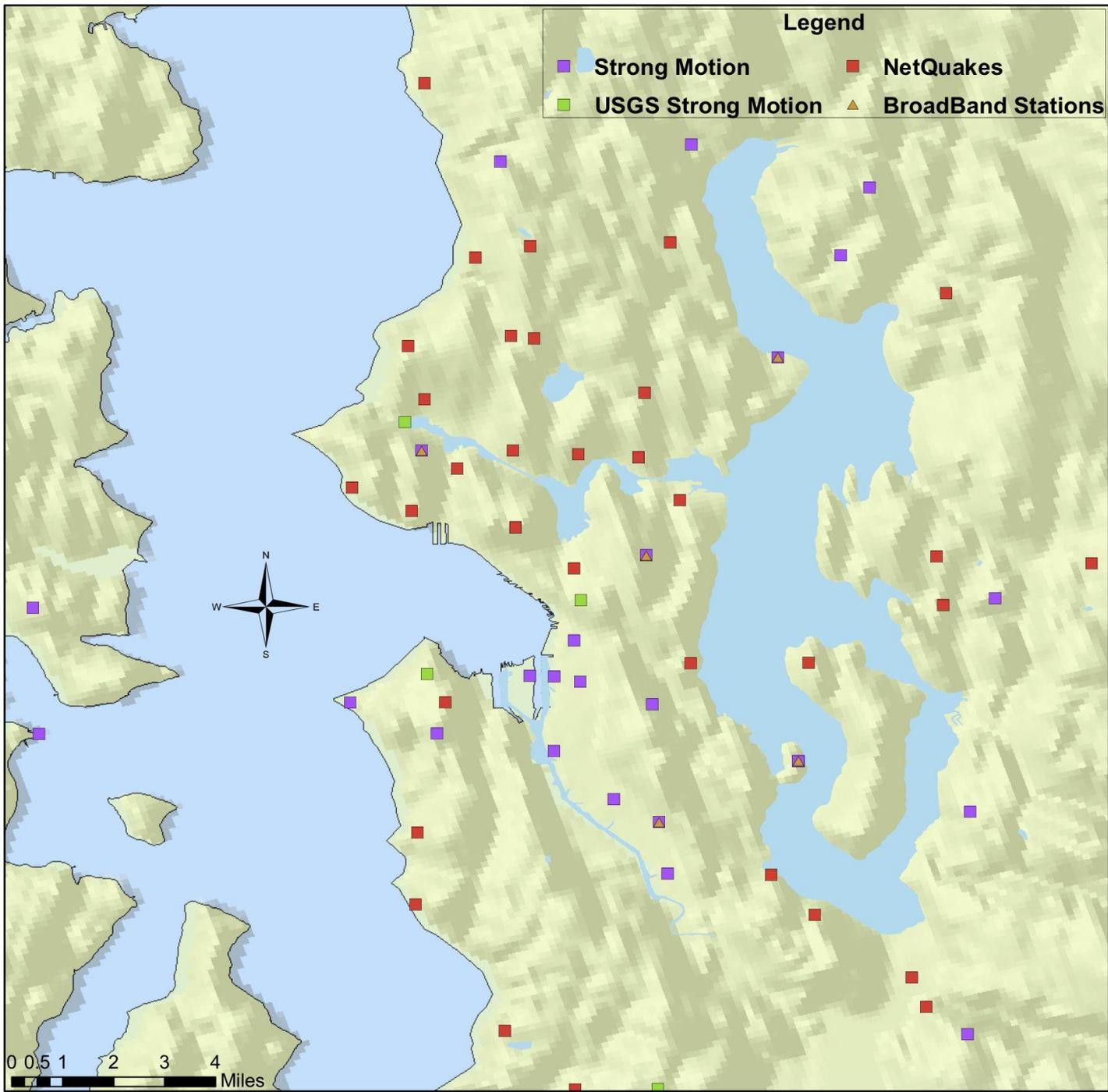


High-gain

- ◆ 65 new PNW Netquakes (not on Map)

- ◆ Over 1000 total channels of data





Approximate 50 year probabilities:

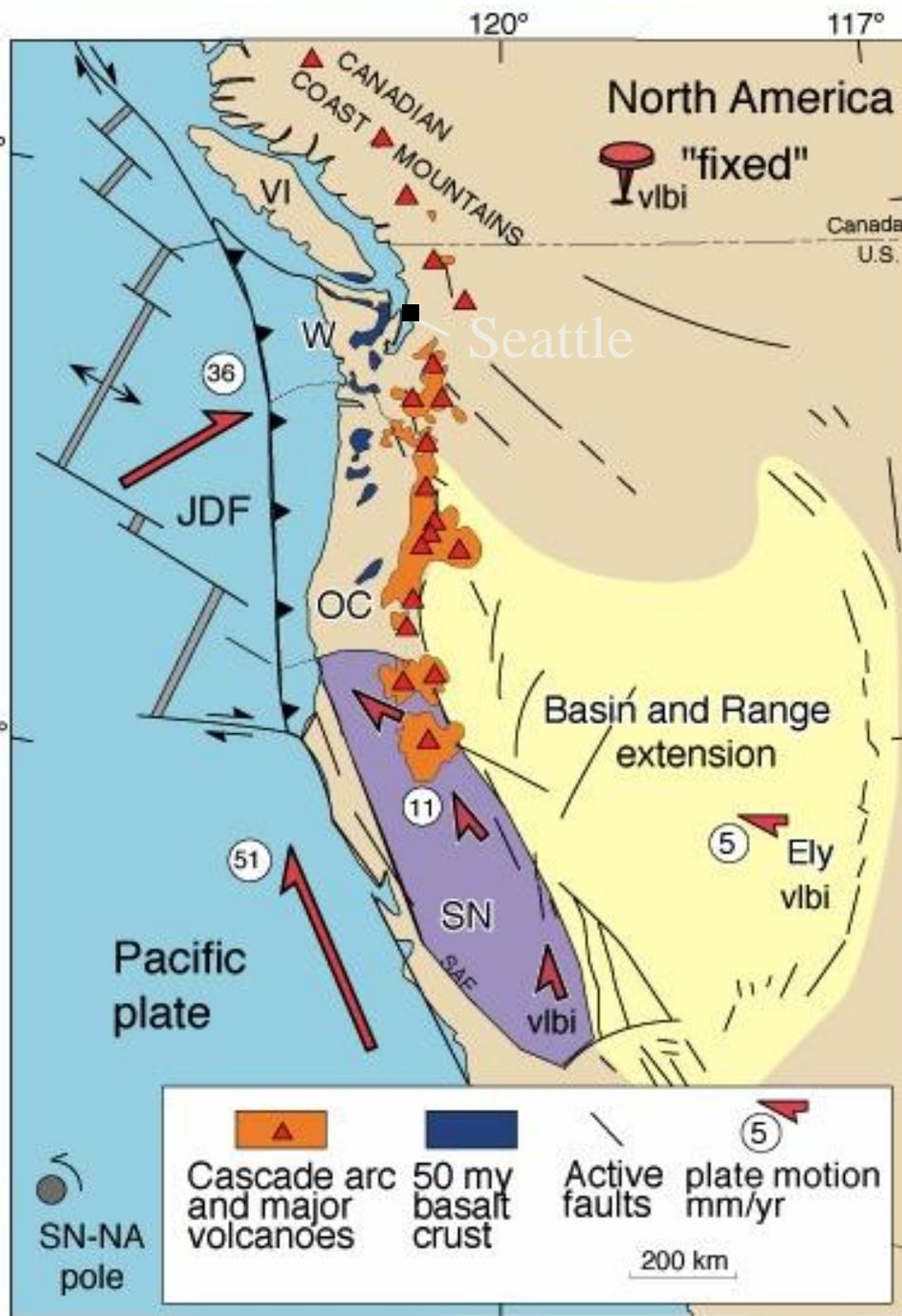
- Cascadia M9: 10-14%
Additional Hazard from M8+ partial rupture
- Seattle Fault $M \geq 6.5$: 5% (from slip rate, GR model; 1000 yr return time) ???
- Deep $M \geq 6.5$: 84% (from 1949, 1965, 2001)
- Random shallow $M \geq 6.5$ in entire Puget Sound area: 15% (mostly from rate of $M \geq 4$ since 1963.)

The Big Picture

The western U.S., including PNW, is deforming over a broad area.

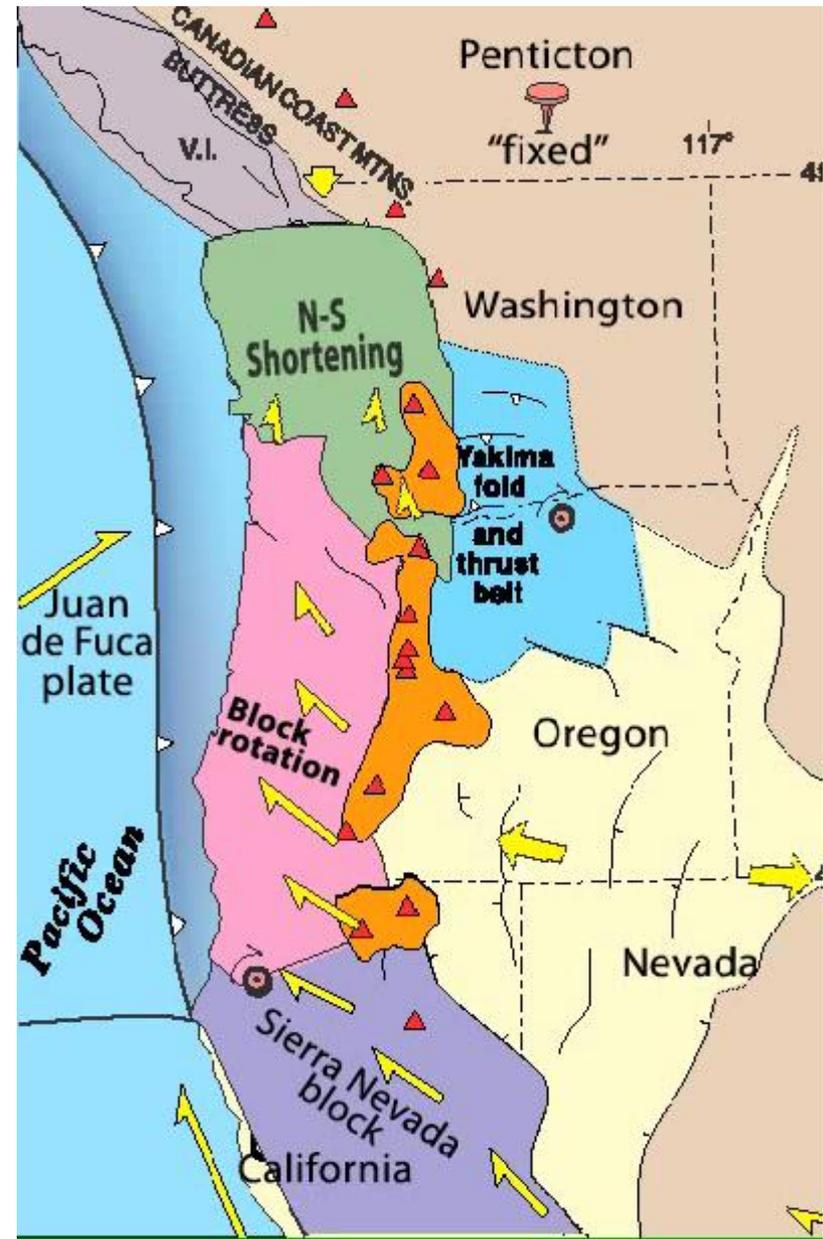
Crustal blocks along continental margin are being dragged northward by the relative motion of the Pacific plate at about 2 in/yr with respect to N. America.

Underthrusting of Juan de Fuca plate is oblique, contributing to northward motion of coastal regions.



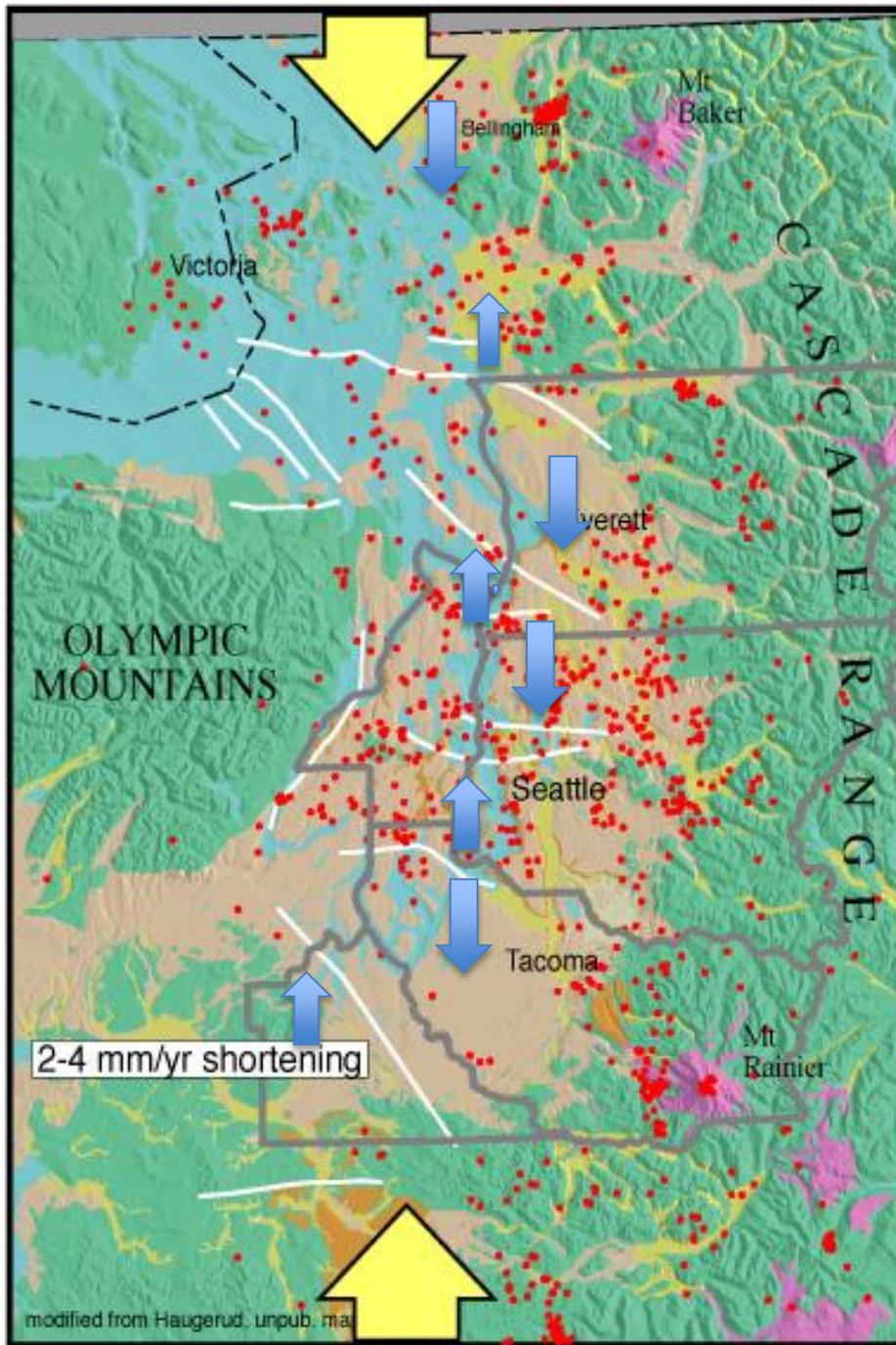
California drives north

Puget Sound Region
faults accommodate all
the resulting deformation.



The Puget Sound Squeeze Box

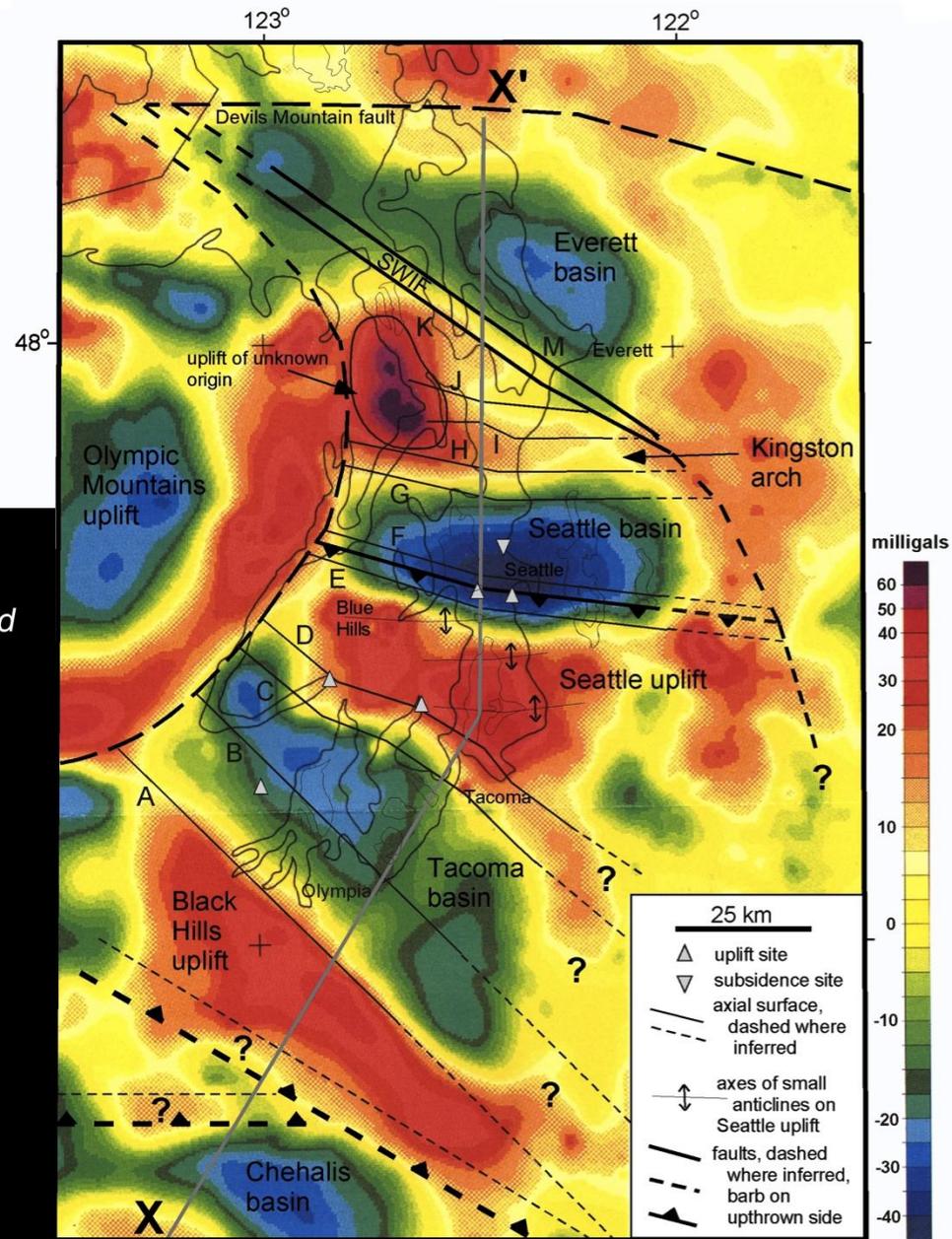
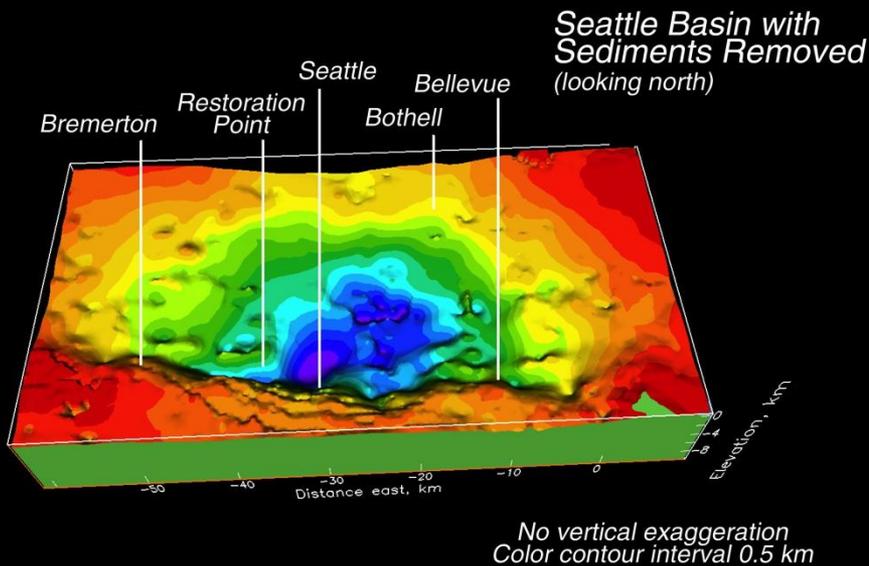
Northward compression causes deformation (faulting) and earthquakes in Puget Sound



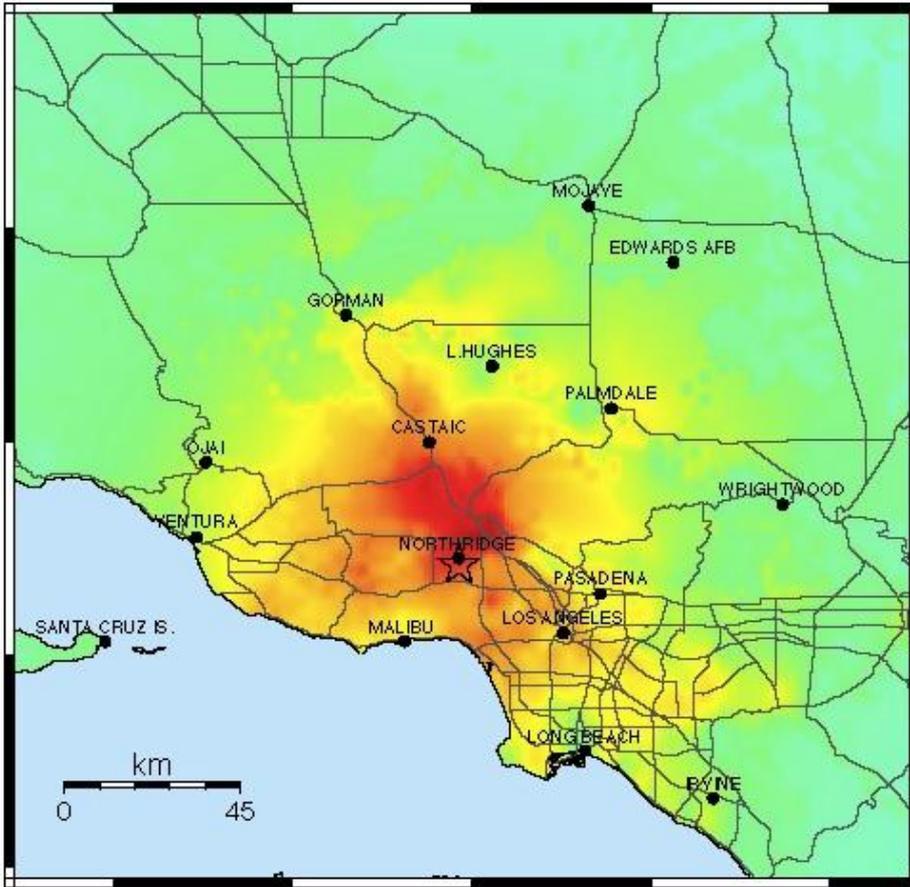
Explanation

-  **Glacial deposits**
-  **Earthquakes**
-  **Crustal Faults**

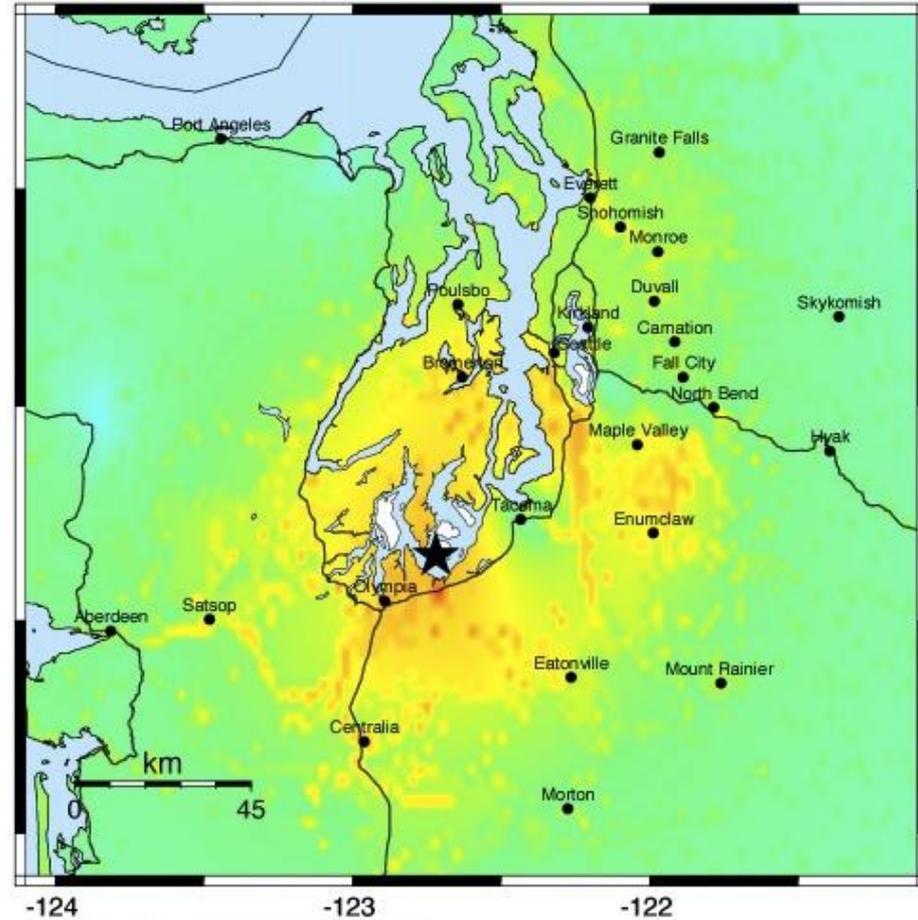
Gravity measurements Reveal deep structure



Northridge, California (M6.7)



Nisqually, Washington (M6.8)



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+

Secondary Impacts

Seattle Liquefaction



Courtesy of Prof. Steve Kramer, Univ.
of Washington

Nisqually Earthquake

- Liquefaction observed in Seattle, Olympia, other areas
- Liquefaction not observed in Puyallup, Kent valley

Near Port of Seattle



Olympia



Seattle Liquefaction Array



- **Critical Need:** How well does current liquefaction theory predict actual behavior of deep liquefiable deposits?



Seattle Liquefaction Array

WHAT?

- State of the art borehole array
- 3 borehole accelerometers, 6 piezometers + 4 surface accelerometers.
- Will measure shaking-caused pore-pressure changes from small-to-great earthquakes.

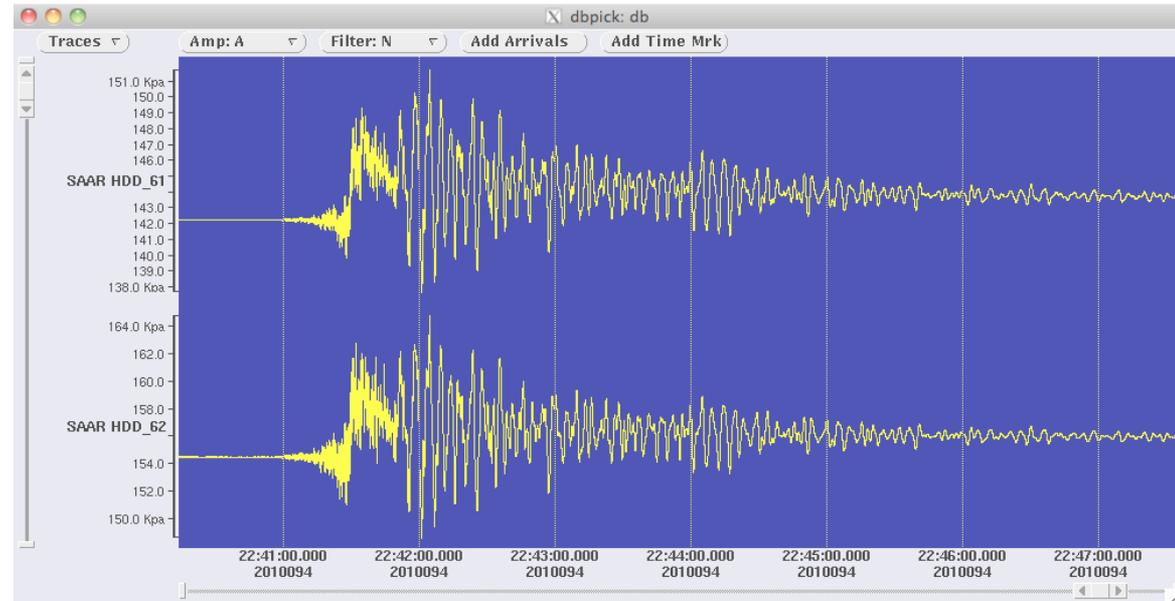
WHERE?

- Stanford Center in SODO.
- Widespread liquefaction during 3 previous earthquakes.

Seattle Liquefaction Array

Collaborators

- USGS
- PNSN
- NEES
- Local geotechs:
Shannon Wilson

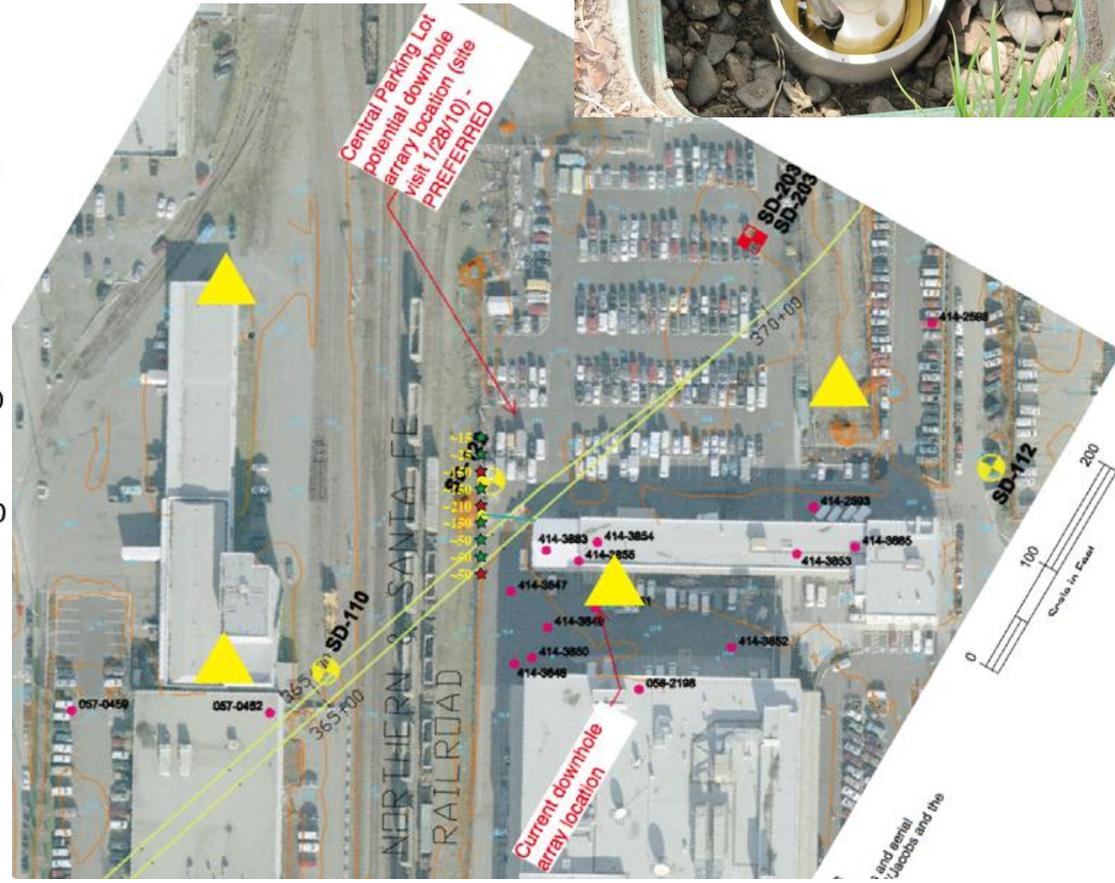
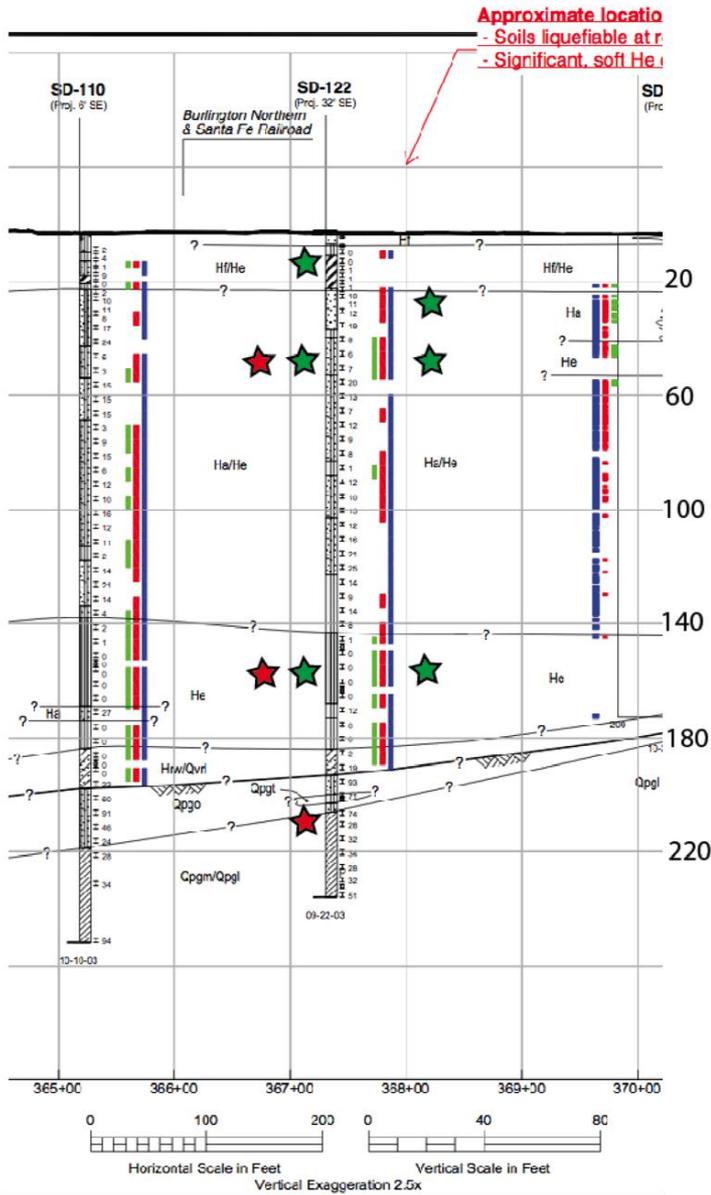


Schedule

- Instrument installation July.
- Completion: Aug.

- Elevated pore pressures at “Wildlife” array from Sierra el Mayor Cucapah earthquake in southern California

Seattle Liquefaction Array

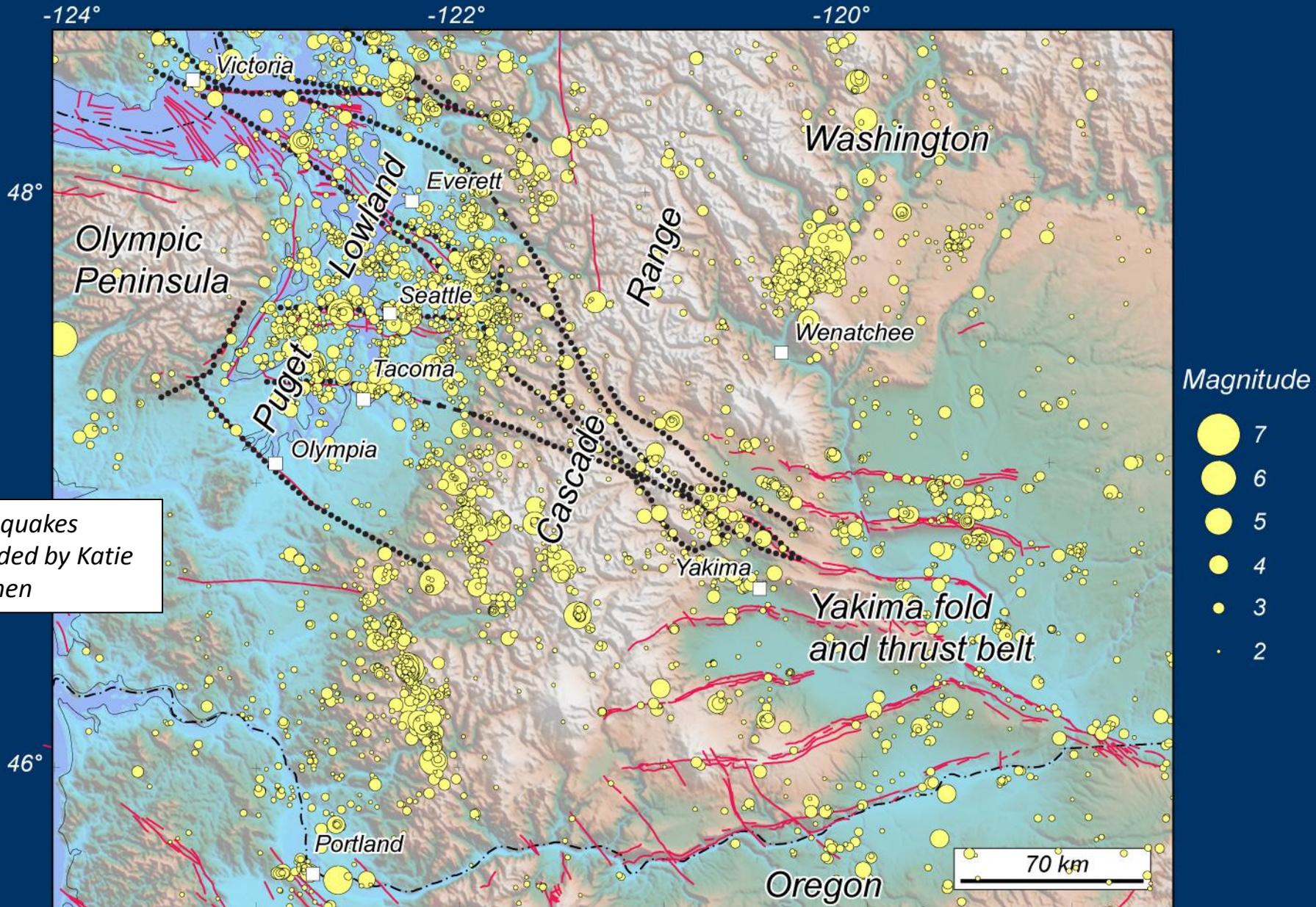


Connecting the Yakima Fold and Thrust Belt to Active Faults in the Puget Sound: Evidence from High-Resolution Aeromagnetic and Regional Gravity Anomalies

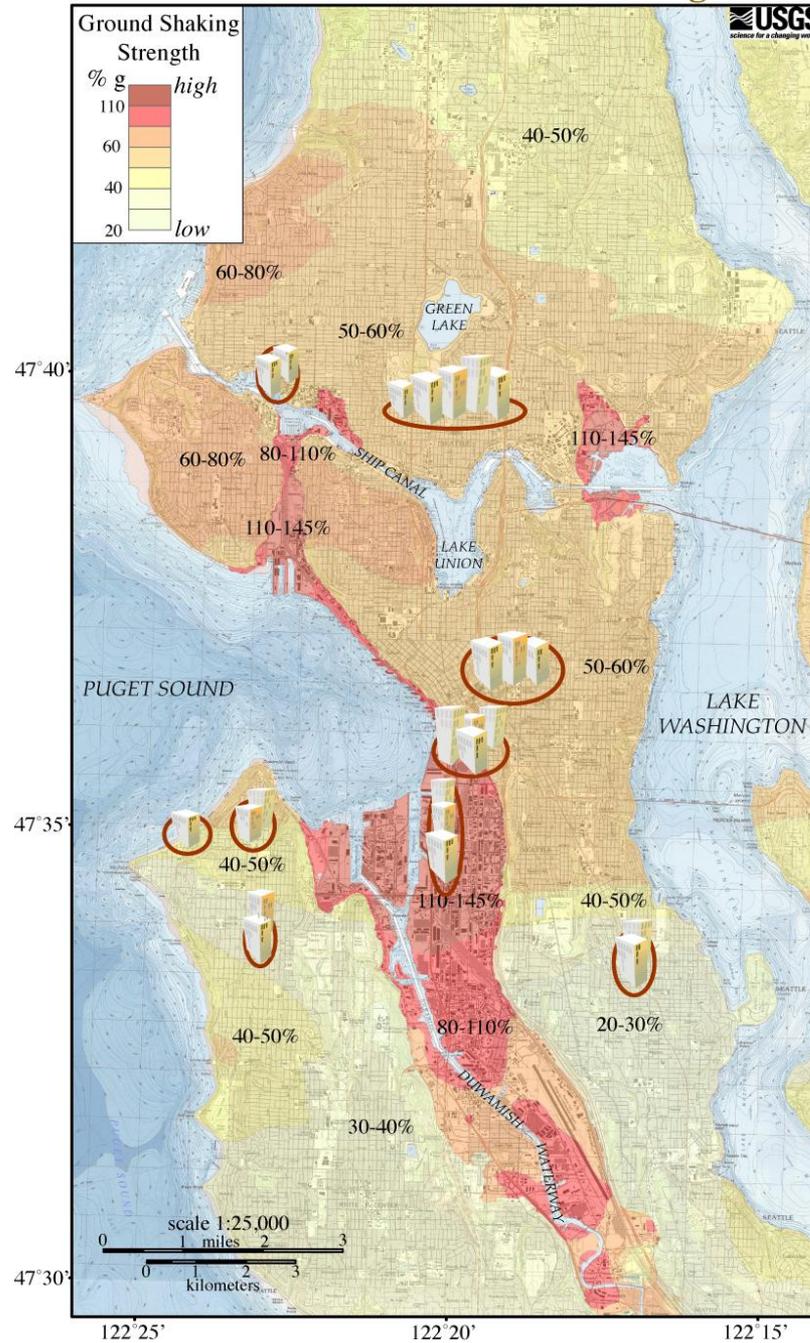
Rick Blakely, Ray Wells, Brian Sherrod, and Craig Weaver



Upper-Plate Earthquakes of Central Washington



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



Hazard maps permit informed prioritization of mitigation efforts.



After September quake



Courtesy Robert Pekelnicky
After February quake

St Paul's church



Locked section of Cascadia subduction zone starts breaking allows warning of strong shaking at large distances

