Seattle Earthquake Risk

City of Seattle URM Policy Committee

Thursday March 8th, 2012

DPD offices, Seattle Municipal Tower

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Historic Deep Earthquakes:

though bad enough, future earthquakes will be larger and stronger

3 Full Pages Quake Pictures Inside

THE WEATHER

Seattle Post-Intelligencer

THE QUALITY NEWSPAPER OF THE GREAT NORTHWEST

SUNRISE EDITION

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

Quake Damage In Millions

Five Dead, Many Hurt In Quake

BY CHARLES DUNSIRE

Western Washington may be declared a dis

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 Wall 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 50 were injured seriously in an earthquake that

The Olympian

SERVING WASHINGTON'S SOUTH PUGET SOUND

MARCH 1, 2001 | www.theolympian.com | 50¢

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

6.8 QUAKE

THE OLYMPIAN STAFF

OLYMPIA — South Sound today will begin to assess the long-term cost from a powerful earthquake that caused widespread damage and left thousands shaken — but, miraculously, few seriously injured.

Many residents will have an unexpected day off as schools and most state offices remain closed while buildings are inspected.

The magnitude 6.8 earthquake struck at 10:55 a.m., lasted about 45 seconds and was centered 30 miles beneath the Nisqually Delta, according to the National Earthquake Information Center in Golden, Colo.

The quake, the area's strongest since 1949, wreaked havoc across South Sound.

■ The city of Olympia evacuated 13 buildings and tagged 14 more as potentially dangerous because of quake damage.

■ The Fourth Avenue bridge in downtown Olympia was closed indefinitely because of damage.

■ The stone exterior of the Capitol dome cracked.

■ Debris from the facades of downtown Olympia buildings littered streets.

■ Northbound lanes of U.S. Highway 101 were closed because of a landslide.

■ Rail traffic ground to a halt after six miles of track were damaged. Sea-Tac Airport also was closed for hours, with planes diverted to Portland, which also felt the quake.

■ More than 50 Olympia residents were at least temporarily displaced from their homes.

In addition to the damage, the quake left thousands of people unnerved.

"It felt like the end of the world," said Casey McKee, an employee of the Fifth Avenue Fabric and Clothing Gallery. "It felt very frightening."

At first McKee thought people upstairs were doing work on the floor, but then she realized it was a quake and ran for the nearest door.

See QUAKE, Page A2

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

Earthquake epicenter

State buildings shut till Monday

BY PATRICK CONDON, BRAD SHANNON AND LAUREN WALSH

THE OLYMPIAN

OLYMPIA — The earthquake that struck South Sound on Wednesday morning shook Washington government to its core, cracking the stone shell of the state Capitol dome and damaging more than 20 state office buildings.

State leaders quickly canceled the legislative session until at least Monday, and more than 10,000 state employees were left without phones or offices to work in when the 6.8 magnitude quake hit at 10:55 a.m.

"There was smoke, and then the sprinklers came on and then there was water running down the marble steps," said Rep. Gigi Talcott, R-Tacoma, describing the chaos on the fourth floor of the John L. O'Brien office building, where many state representatives have their offices.

There were only minor injuries reported on the Capitol Campus, according to the Olympia Fire Department.

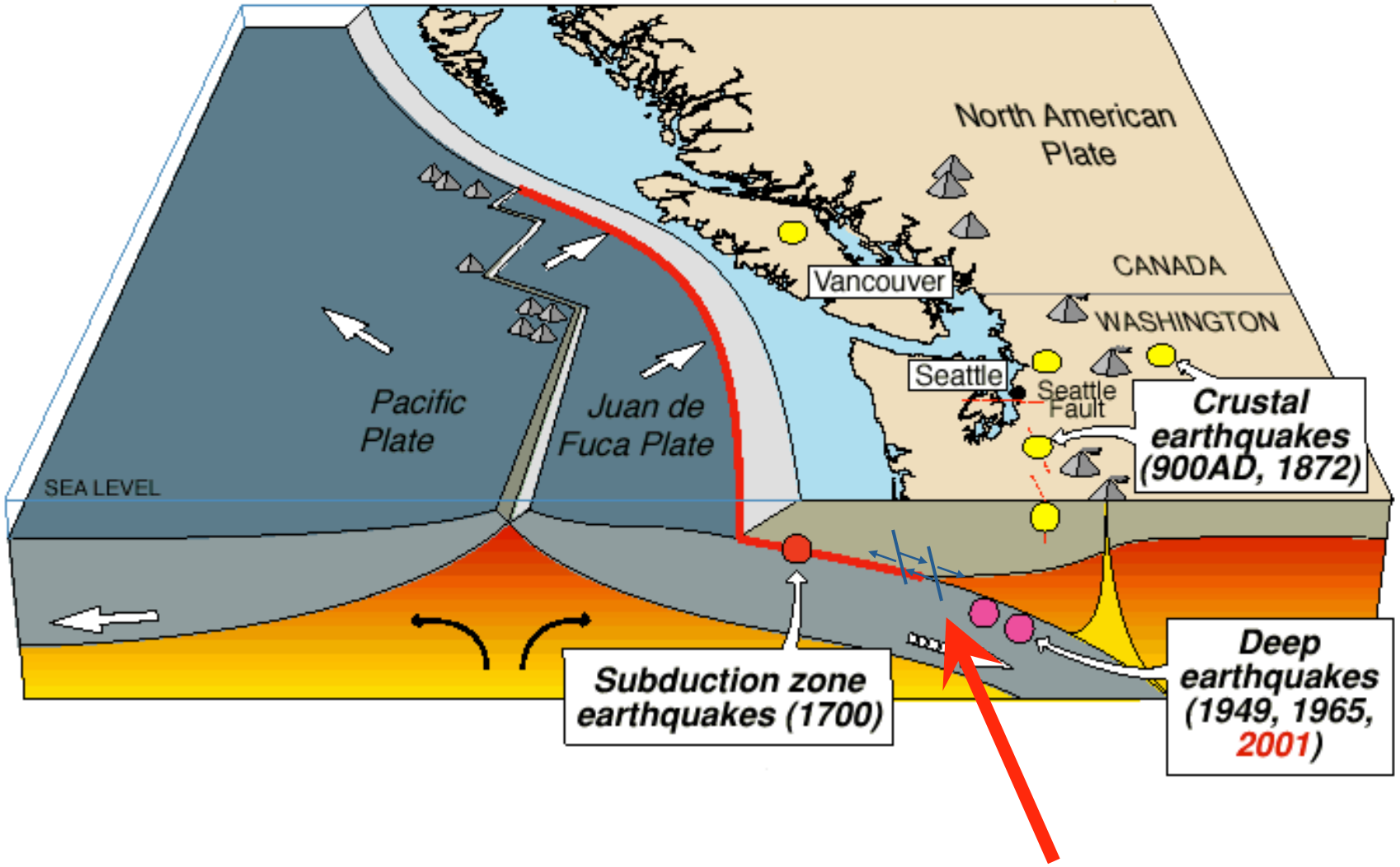
See CAPITOL, Page A2

2001

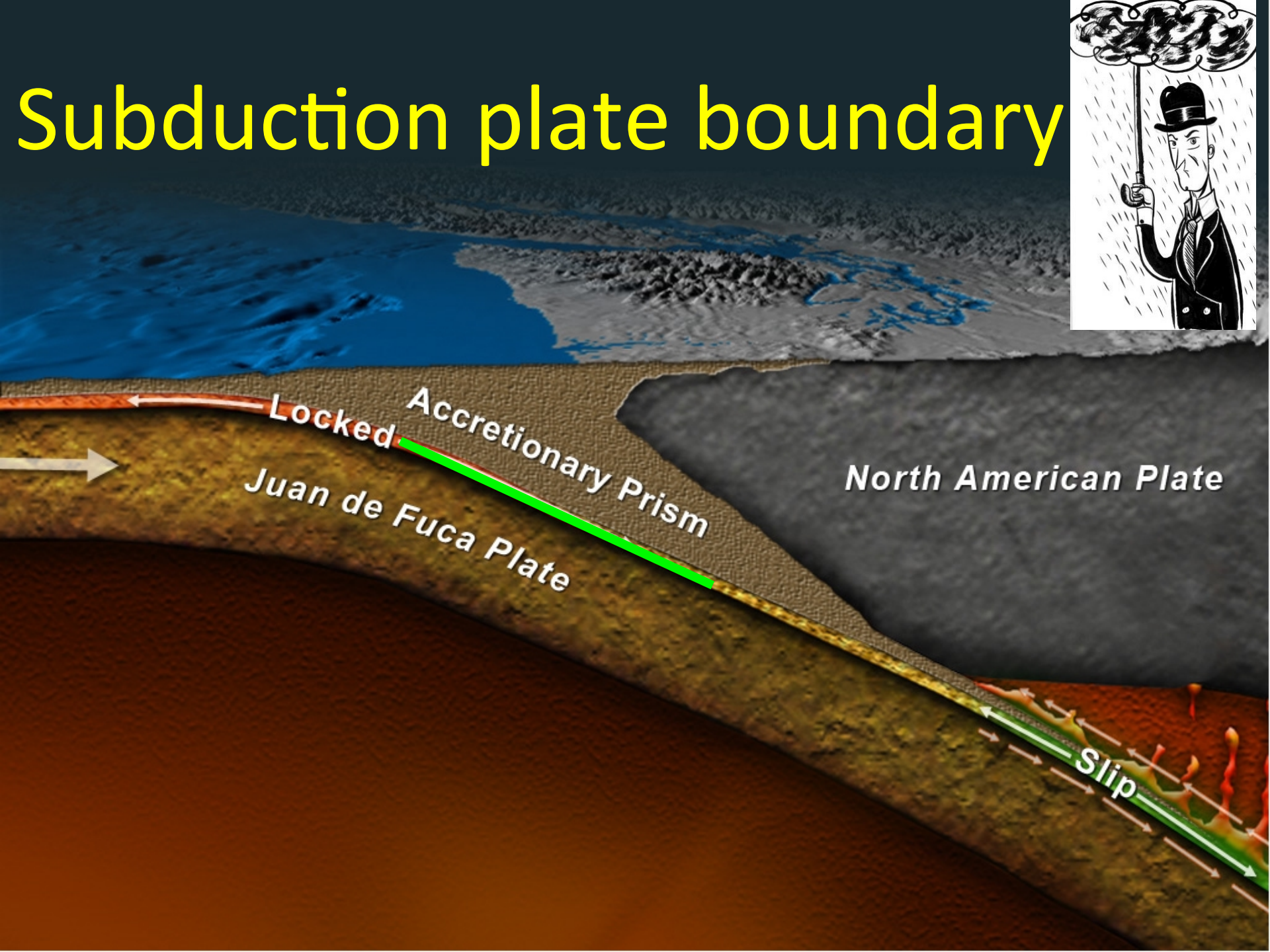
4th Ave. bridge | Residents: 'Our building was dancing'

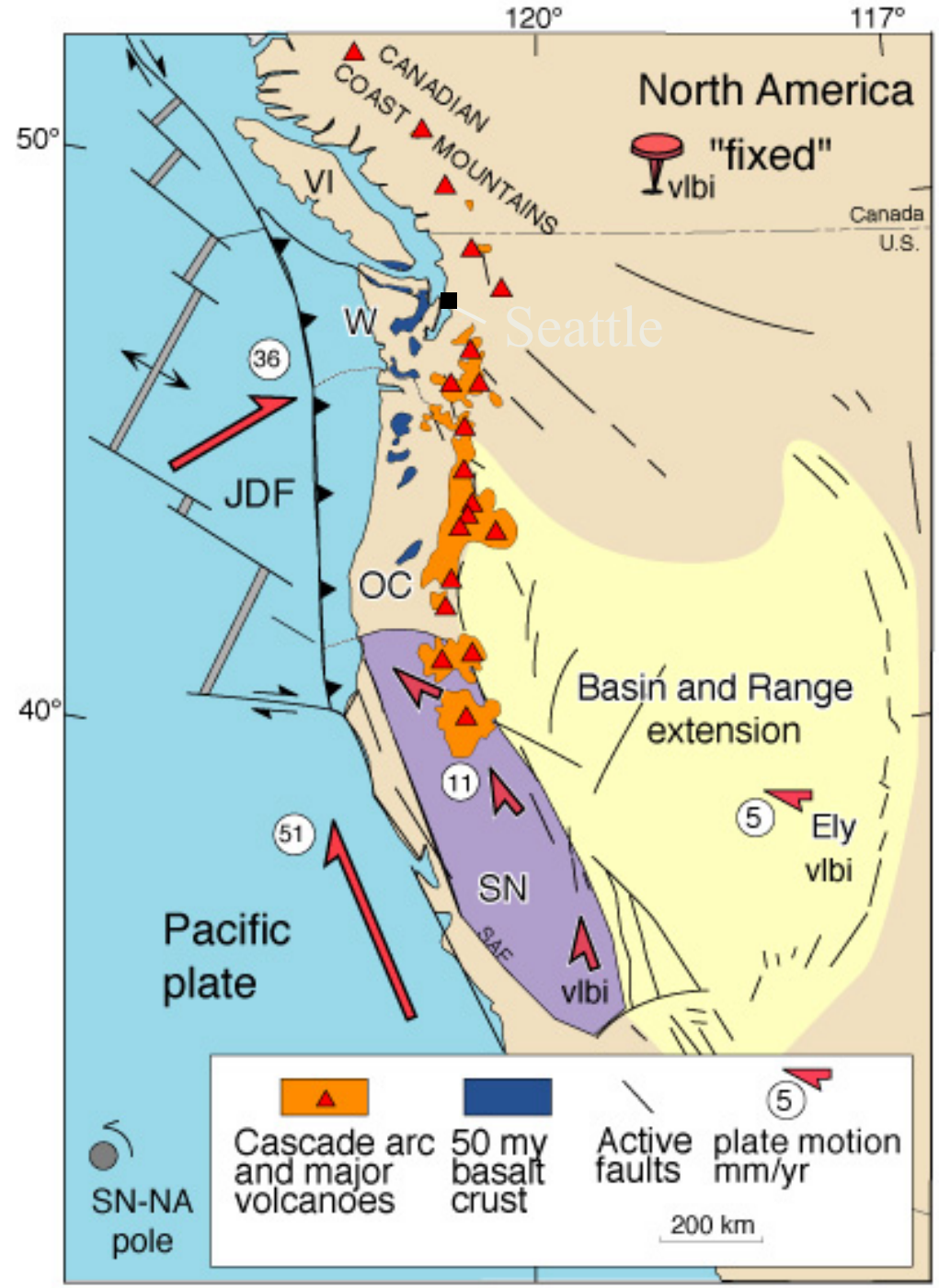
Pacific Northwest Seismicity

Puget Sound Area Earthquake Sources



Subduction plate boundary



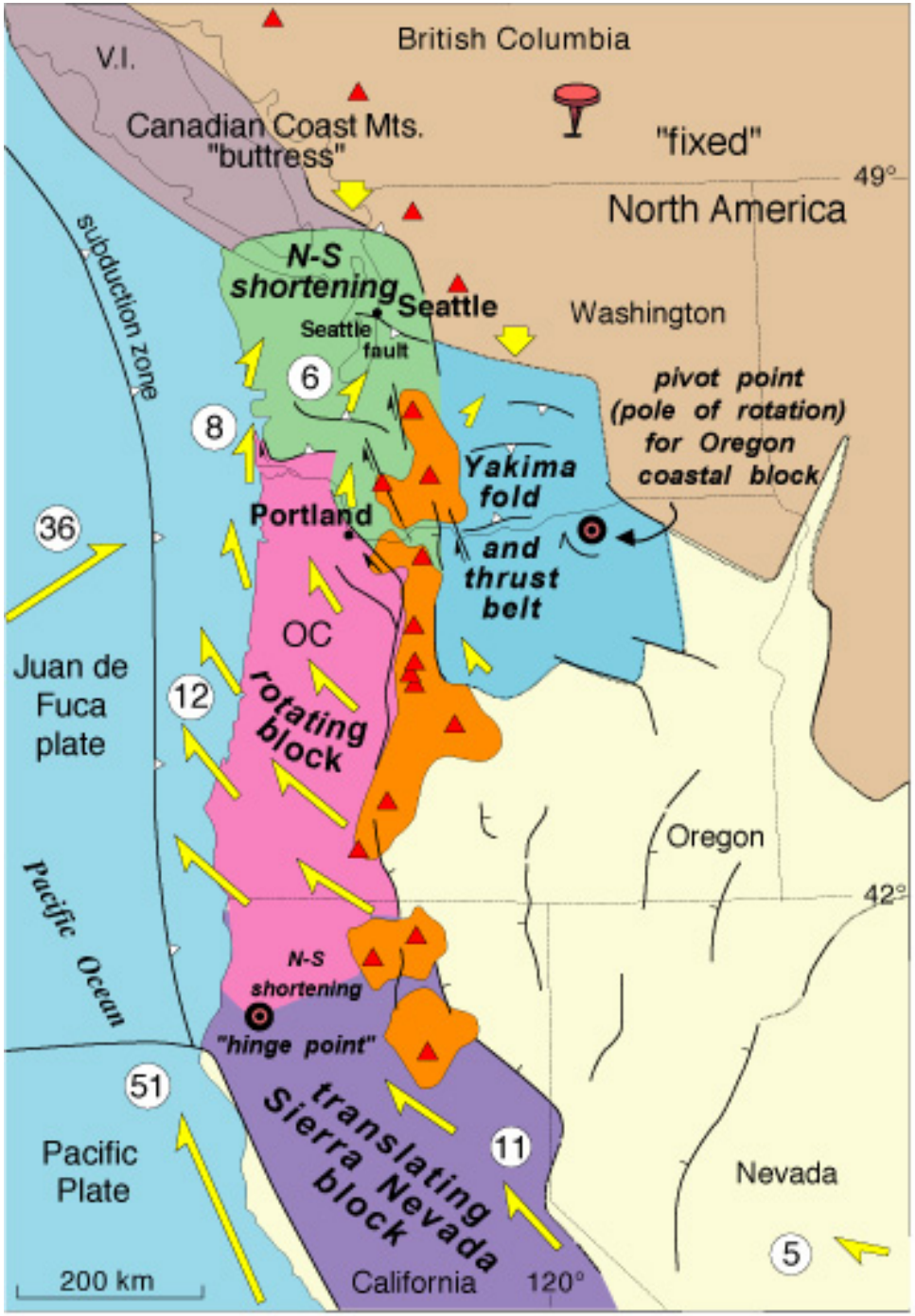


The Big Picture

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.



Block tectonic model for PNW

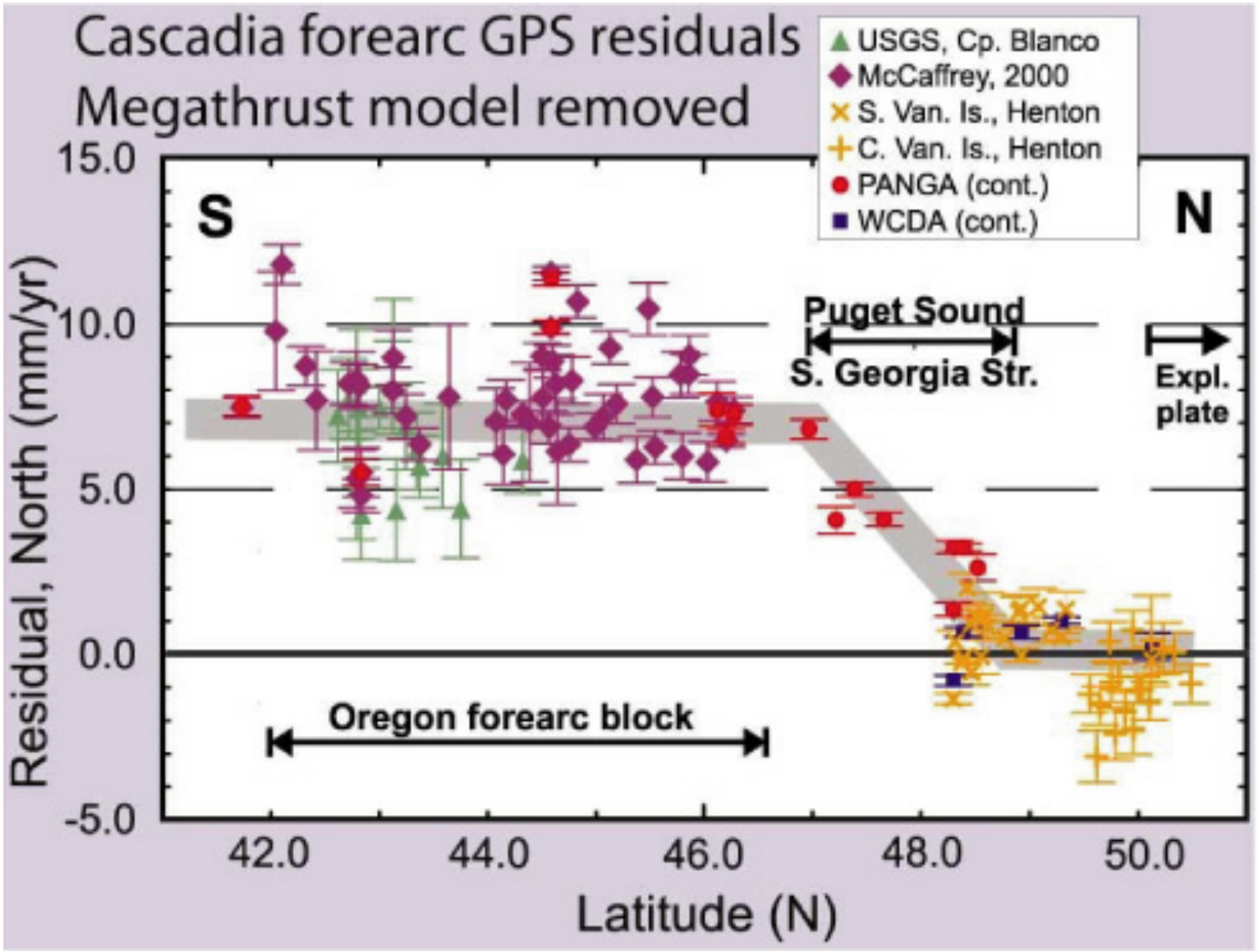
Oregon coastal block rotates clockwise at 12 mm/yr, putting the squeeze on western Washington

Explanation

- motion w/ respect to stable N. America in millimeters per yr (divide by 25 to get inches) (10)
- large volcano & young volcanic rocks
- thrust fault (crustal shortening)
- normal fault (crustal spreading)

Wells and Simpson, 2001; after Wells et al., 1998

Oregon's northward motion squeezes Puget lowland



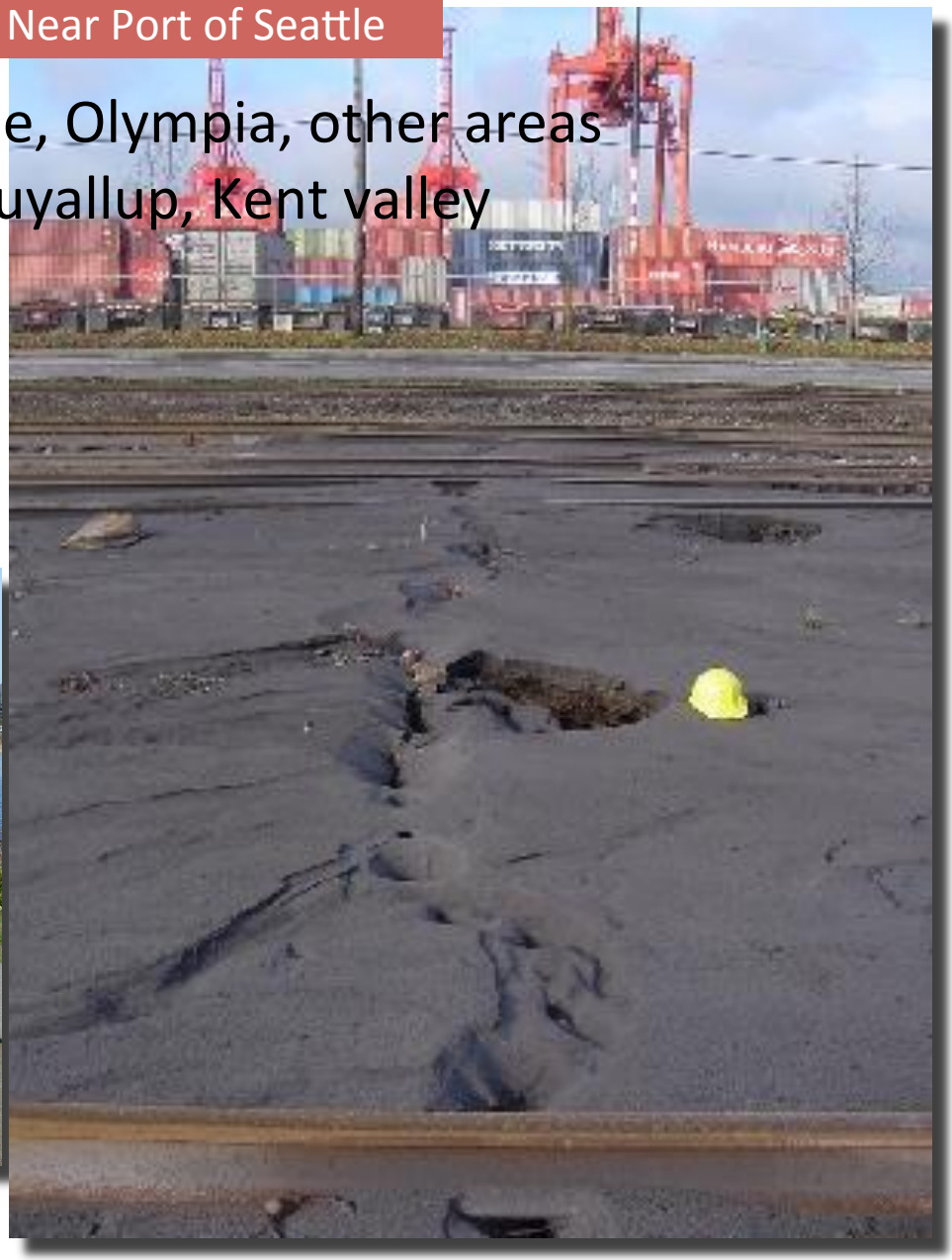
The buck stops here…

Nisqually Earthquake

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

Soil Liquefaction

Near Port of Seattle



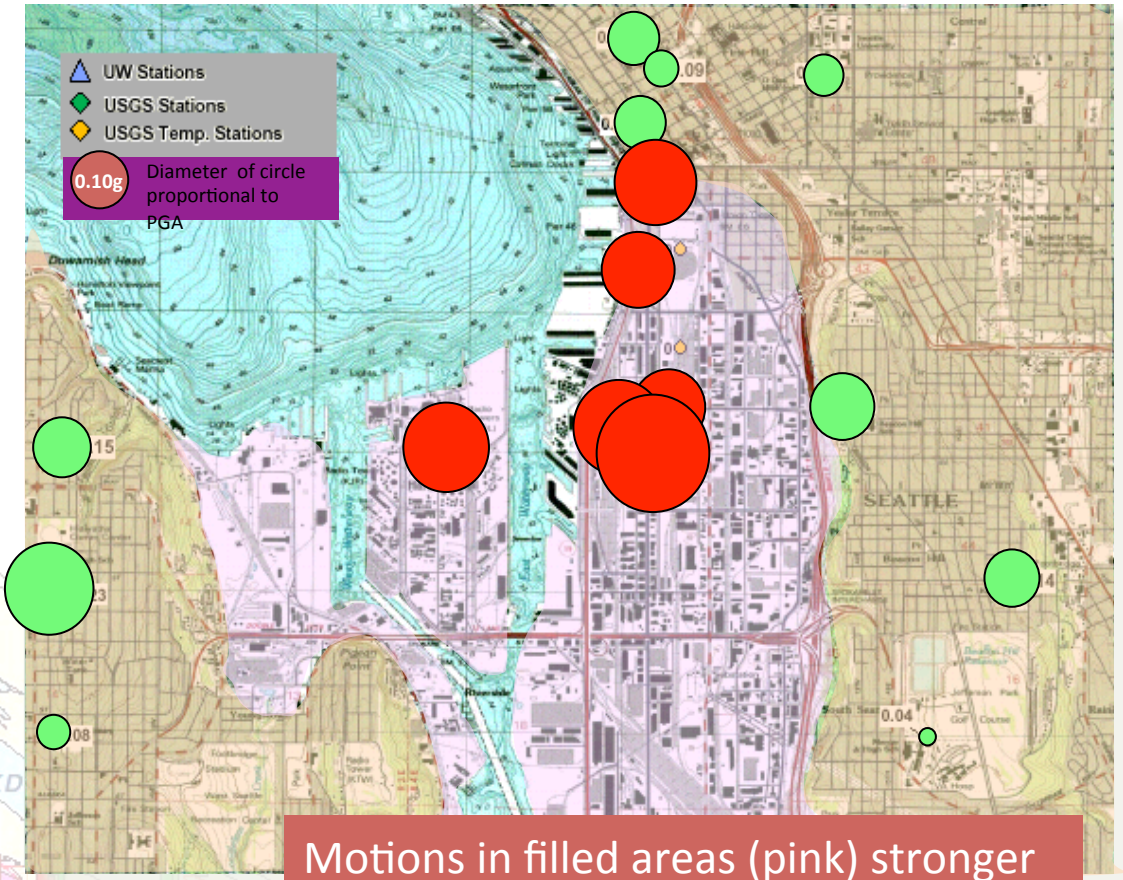
Olympia

Steve Kramer, UW, slide

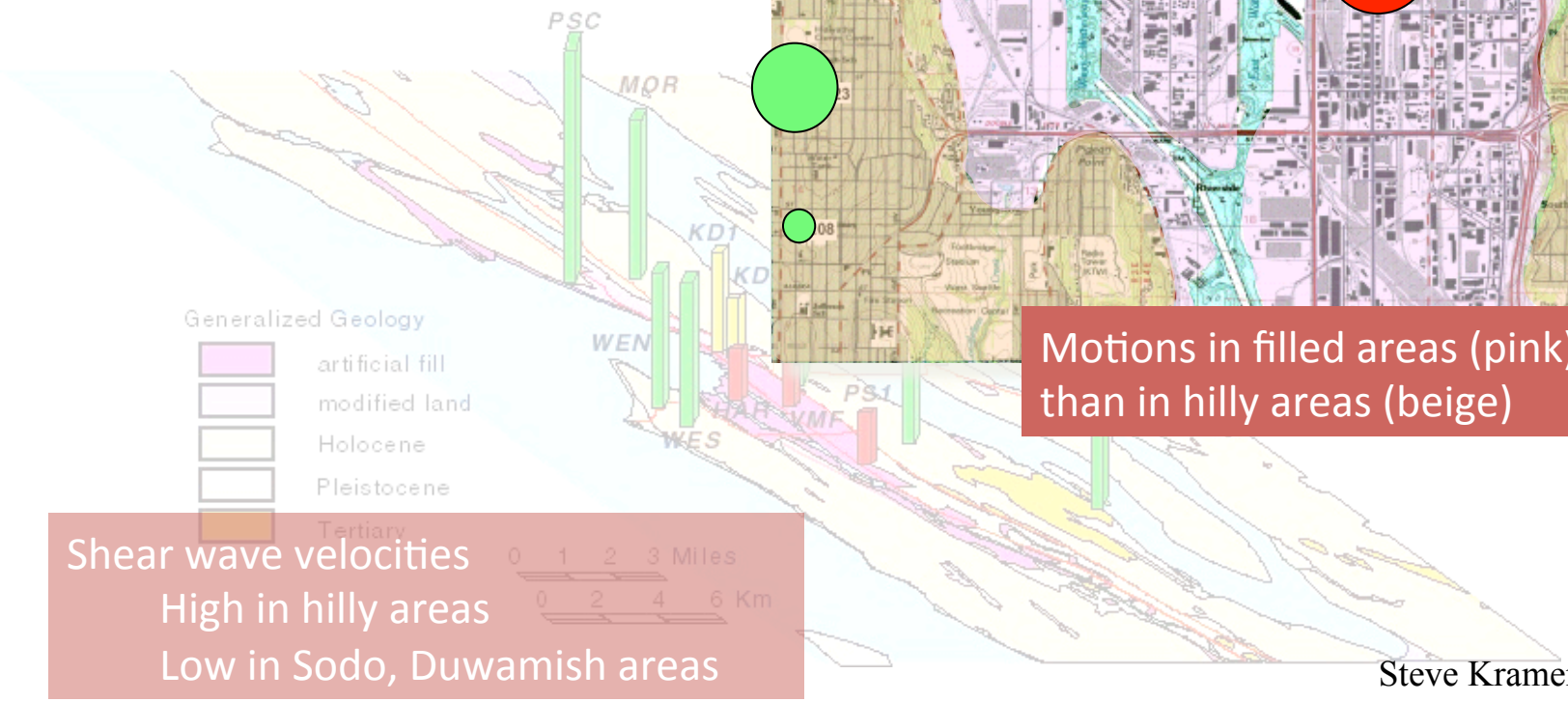
Soil Amplification

Depends on:

- Soil type
- Soil stiffness
- Soil thickness
- Soil geometry



Motions in filled areas (pink) stronger than in hilly areas (beige)



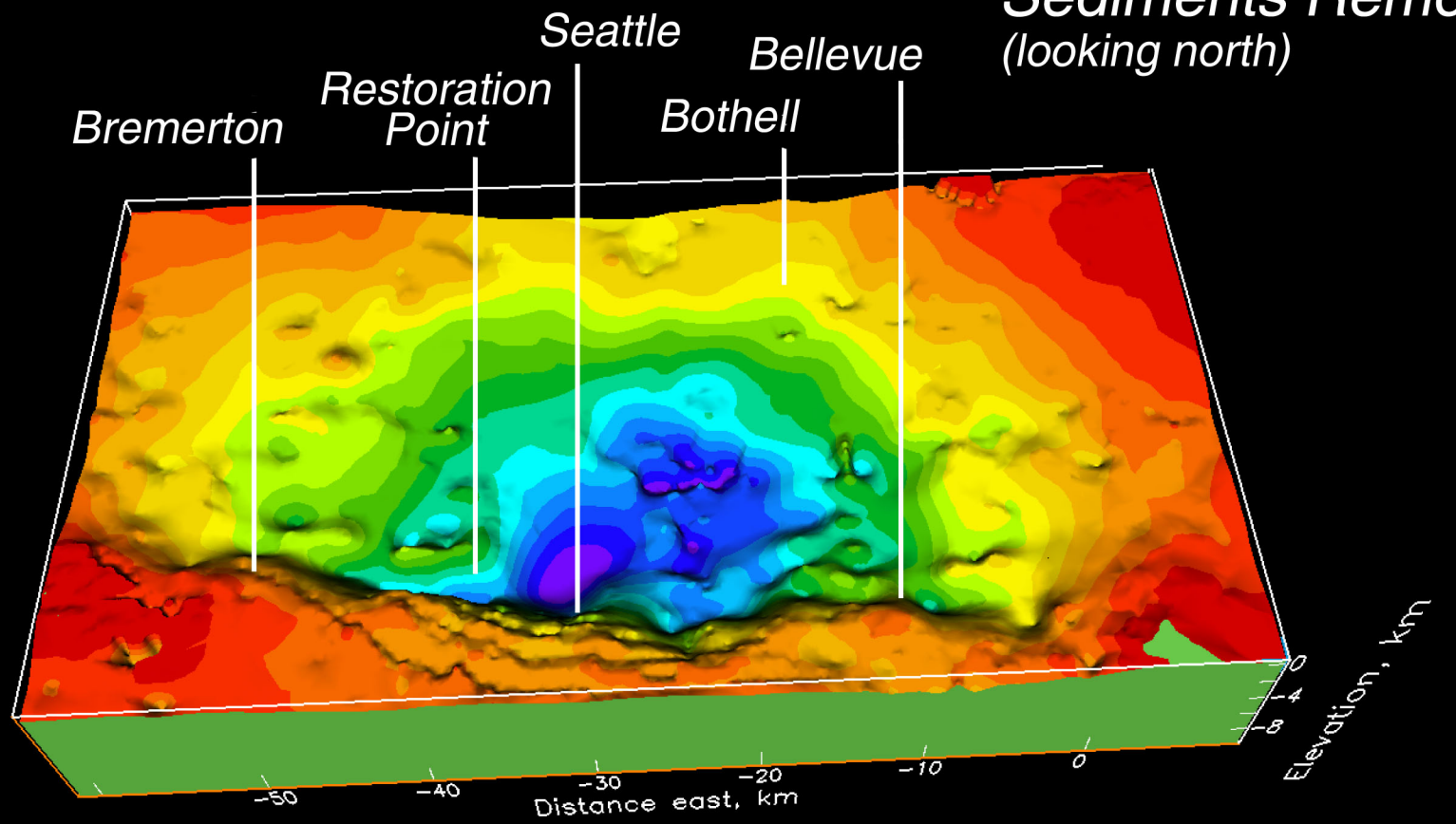
Shear wave velocities

- High in hilly areas
- Low in Sodo, Duwamish areas

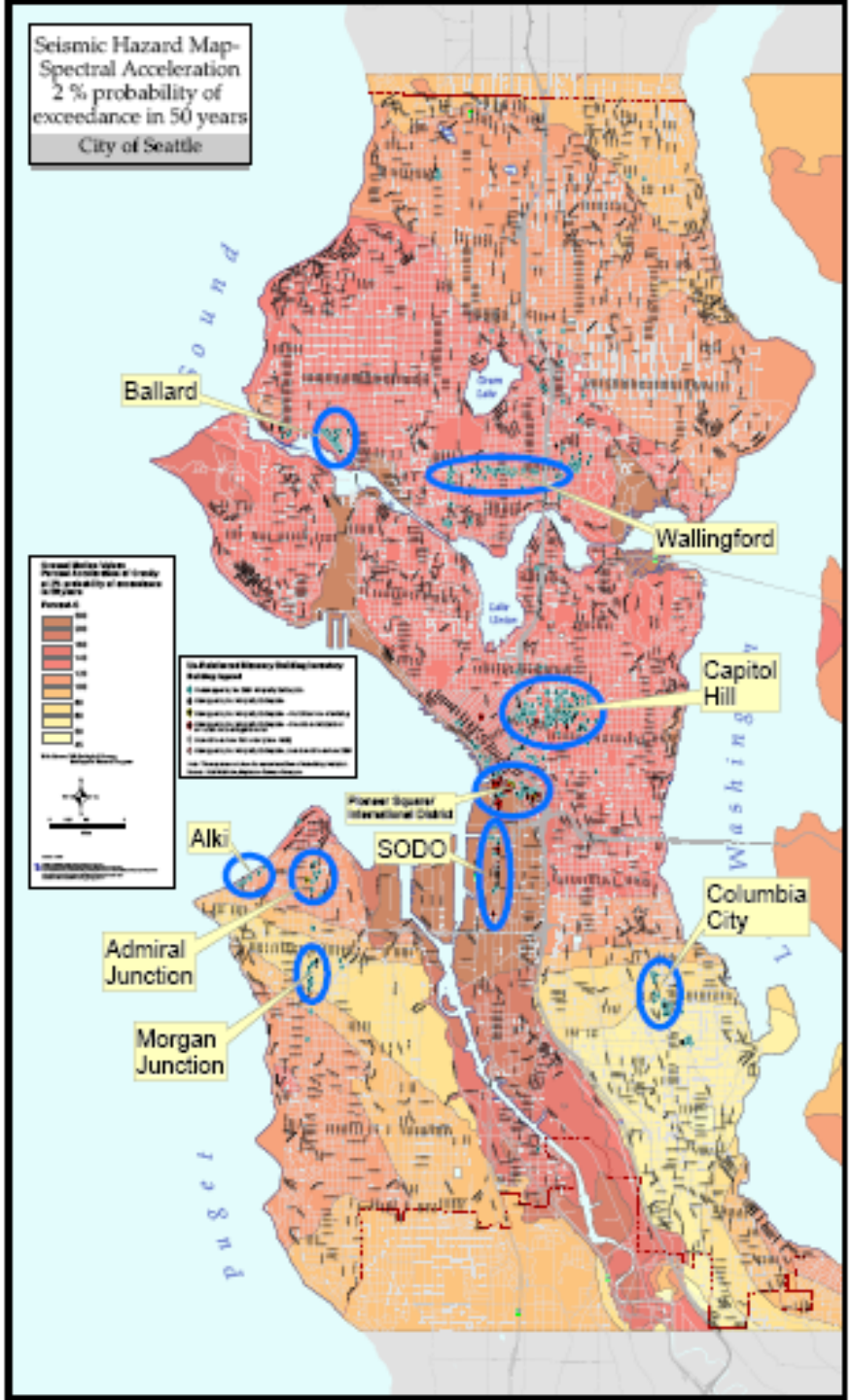
Steve Kramer, UW, slide

Seattle Basin with Sediments Removed

(looking north)



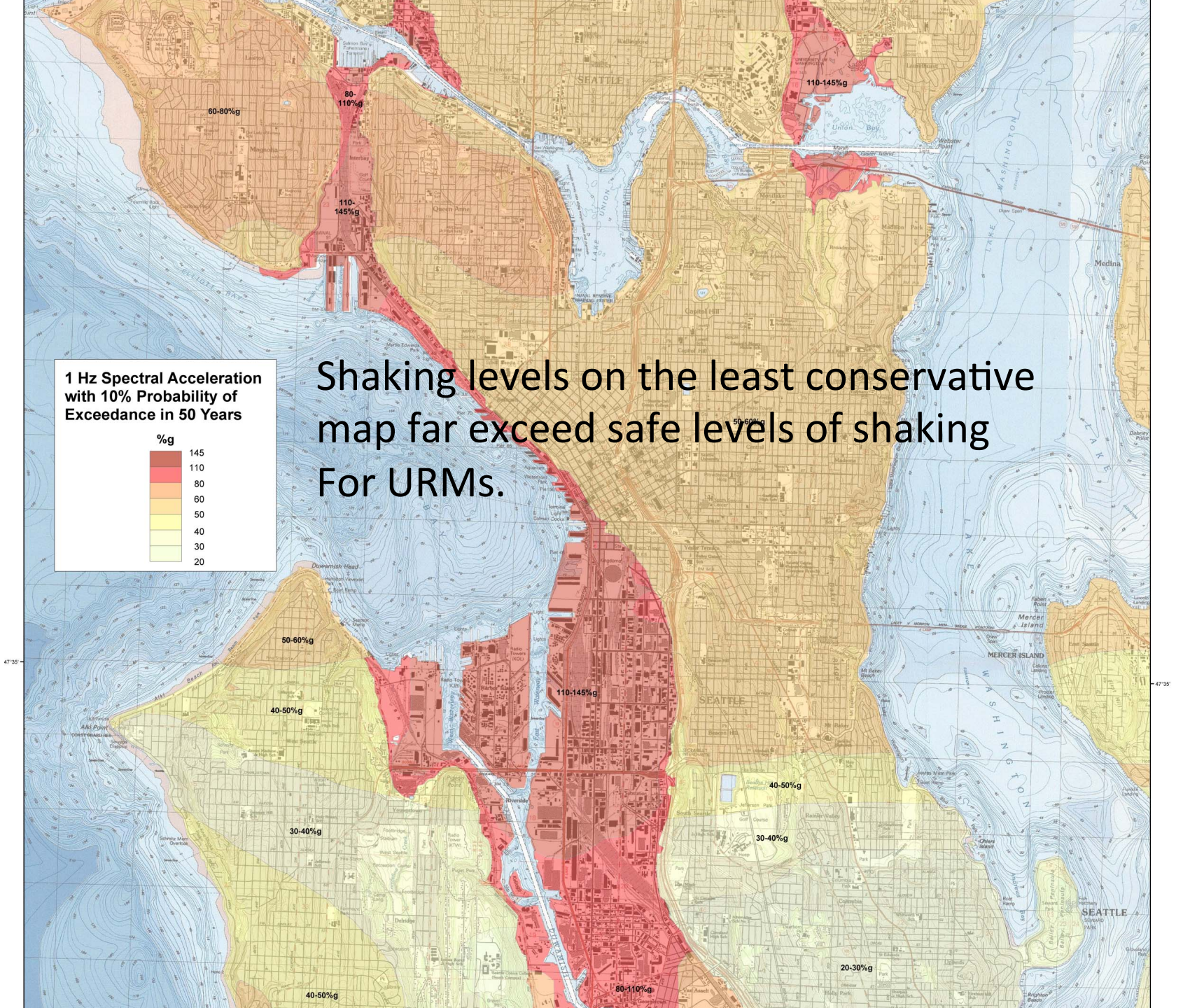
No vertical exaggeration
Color contour interval 0.5 km



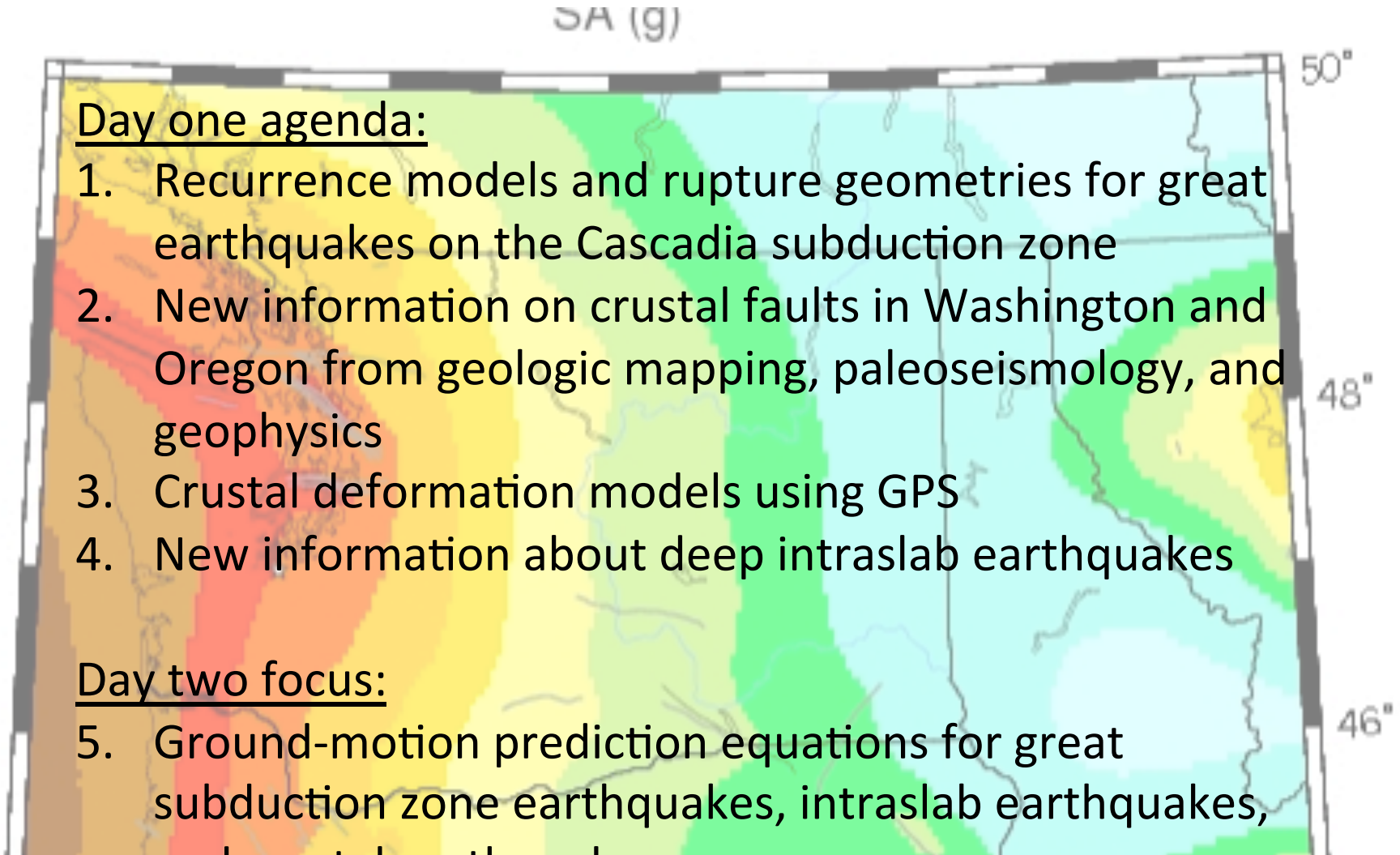
Unreinforced Masonry Building locations in Seattle plotted on USGS urban seismic hazard map showing spectral accelerations with 2% probability of exceedance in 50 years.

Urban seismic hazard maps
useful for identifying areas with strongest expected shaking;
useful for identifying vulnerable links in Infrastructure and emergency response

Map from City of Seattle
Unreinforced Masonry Building Seismic Hazards Study, 2007


1 Hz Spectral Acceleration with 10% Probability of Exceedance in 50 Years
%g
145
110
80
60
50
40
30
20
Shaking levels on the least conservative map far exceed safe levels of shaking For URMs.
60-80%g
80-110%g
110-145%g
110-145%g
50-60%g
50-60%g
110-145%g
40-50%g
40-50%g
30-40%g
30-40%g
40-50%g
80-110%g
20-30%g
SEATTLE
MERCER ISLAND
Medina
47°35'
47°35'

National Seismic Hazard Mapping Project
Pacific Northwest Workshop
March 21-22, University of Washington



<u>Day one agenda:</u>

1. Recurrence models and rupture geometries for great earthquakes on the Cascadia subduction zone
2. New information on crustal faults in Washington and Oregon from geologic mapping, paleoseismology, and geophysics
3. Crustal deformation models using GPS
4. New information about deep intraslab earthquakes

<u>Day two focus:</u>

5. Ground-motion prediction equations for great subduction zone earthquakes, intraslab earthquakes,