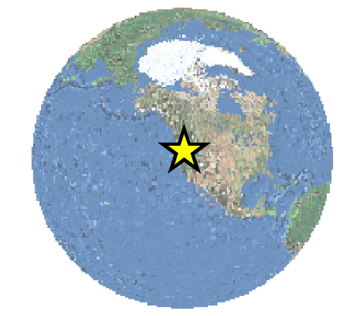
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

EARTHQUAKE SUMMARY MAP

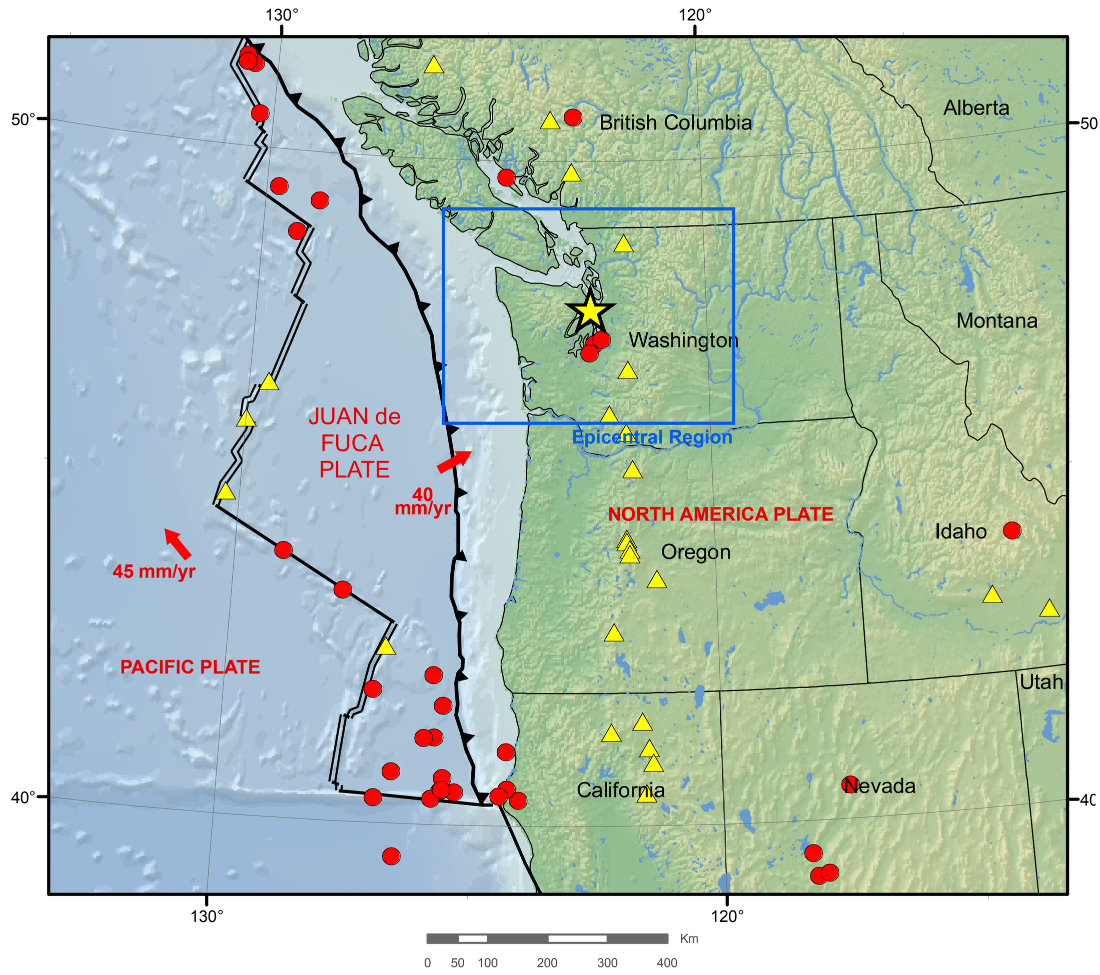
Prepared in cooperation with:

ANSS
PNSN Pacific Northwest Seismic Network

M4.5 Kingston Earthquake of 30 January 2009



Tectonic Setting



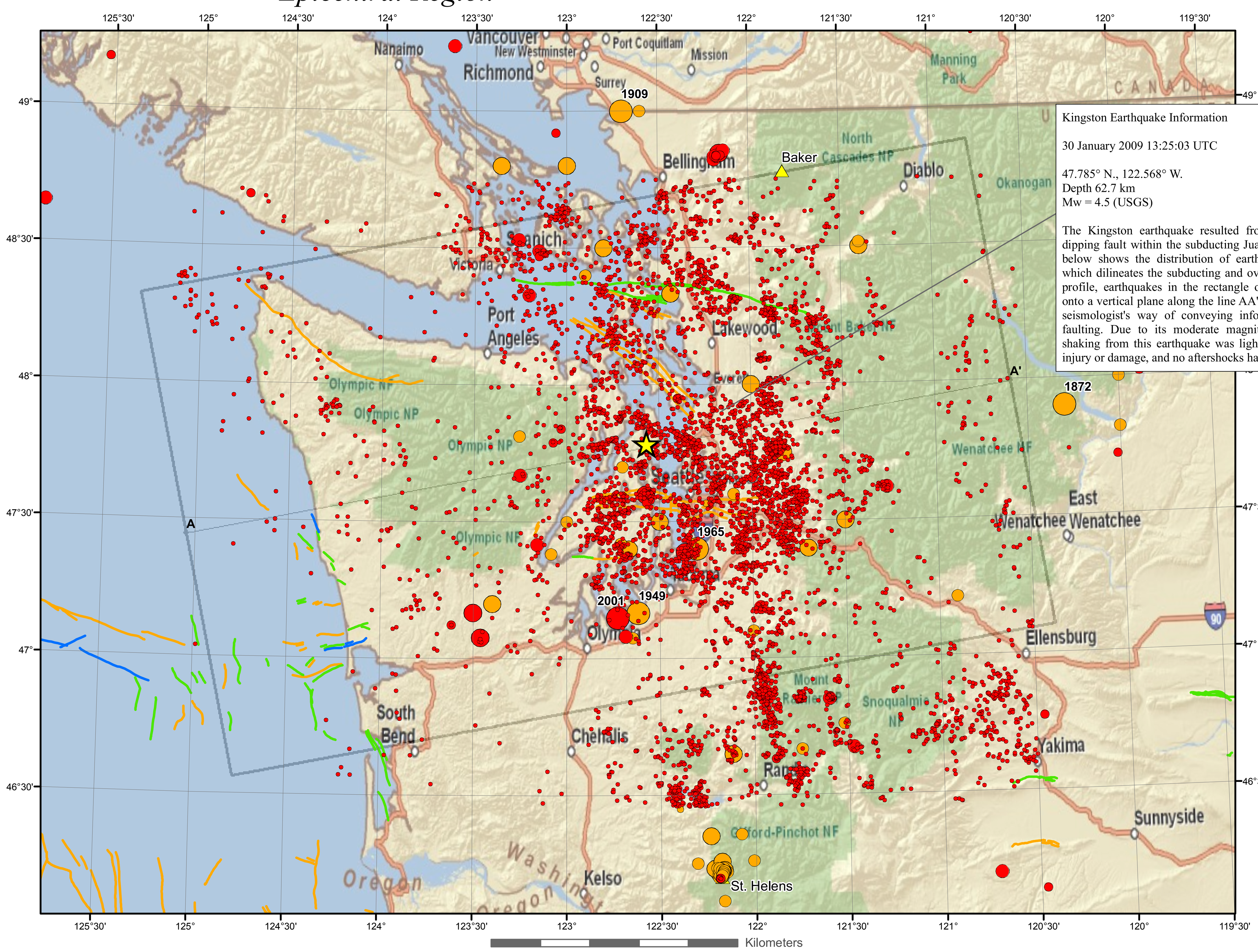
EXPLANATION

- Main Shock
- **Mag ≥ 6.5 1900 - 2002**
  - 0 - 69 km
  - 70 - 299
- **Plate Boundary (type)**
  - Subduction
  - Transform
  - Divergent
  - Others
  - Active Volcanoes

RELATIVE PLATE MOTIONS

The broad red vectors represent plate motions in the region. The Pacific Plate is generally moving 45 mm/yr northwestward with respect to the North America Plate. The Juan de Fuca plate is moving about 40 mm/yr east northeast relative to the North America Plate.
This relative motion, and resistance to it, gives rise to the tectonic processes that create mountains, volcanoes, and earthquakes in the region.

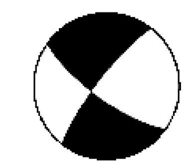
Epicentral Region



Kingston Earthquake Information

30 January 2009 13:25:03 UTC

47.785° N., 122.568° W.
Depth 62.7 km
Mw = 4.5 (USGS)



The Kingston earthquake resulted from strike-slip motion on a dipping fault within the subducting Juan de Fuca plate. The figure below shows the distribution of earthquakes in a depth profile, which dilineates the subducting and overlying plates. To make the profile, earthquakes in the rectangle on this map were projected onto a vertical plane along the line AA'. The beachball (above) is a seismologist's way of conveying information about the type of faulting. Due to its moderate magnitude and deep hypocenter, shaking from this earthquake was light. There were no reports of injury or damage, and no aftershocks have been detected.

EXPLANATION

- Main Shock
- **1990 - 2008**
  - M 1.0 - 3.5
  - 3.5 - 3.9
  - 4.0 - 4.9
  - 5. 0 -5.9
  - 6.0 - 7.6
- **1769 - 1989**
  - M 3.5 - 3.9
  - 4.0 -4.9
  - 5.0 -5.9
  - 6.0 - 7.6
- **Quaternary Faults AGE**
  - <150 years
  - <15,000
  - <130,000
  - <750,000

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M 4.5, 8.1 km NE of Poulsbo, WA — **PAGER Version 5**

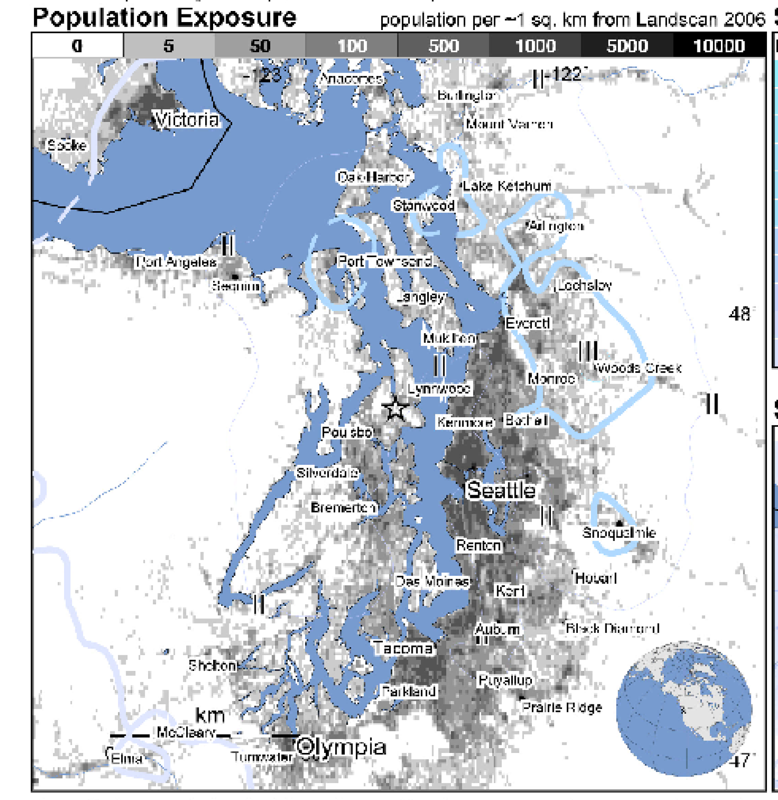
Origin Time: Fri 2009-01-30 13:25:00 UTC
Location: 47.79°N 122.57°W Depth: 62 km
Created: 4 days, 10 hrs after earthquake

Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)		42k*	4,354k*	0	0	0	0	0	0	0
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure population per ~1 sq. km from Landscan 2006

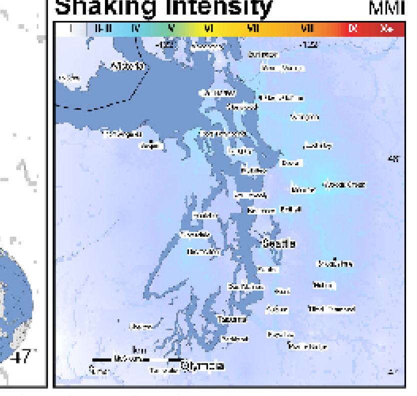


Selected City Exposure

MMI	City	Population
III	**Woods Creek**	4k
III	Sultan	3k
III	**Port Townsend**	8k
III	Fall City	1k
III	**Snoqualmie**	8k
III	North Bend	4k
II	**Seattle**	569k
II	Bellevue	111k
II	**Tacoma**	196k
II	**Olympia**	44k
II	**Victoria**	289k

bold cities appear on map (k = x1000)

Shaking Intensity MMI

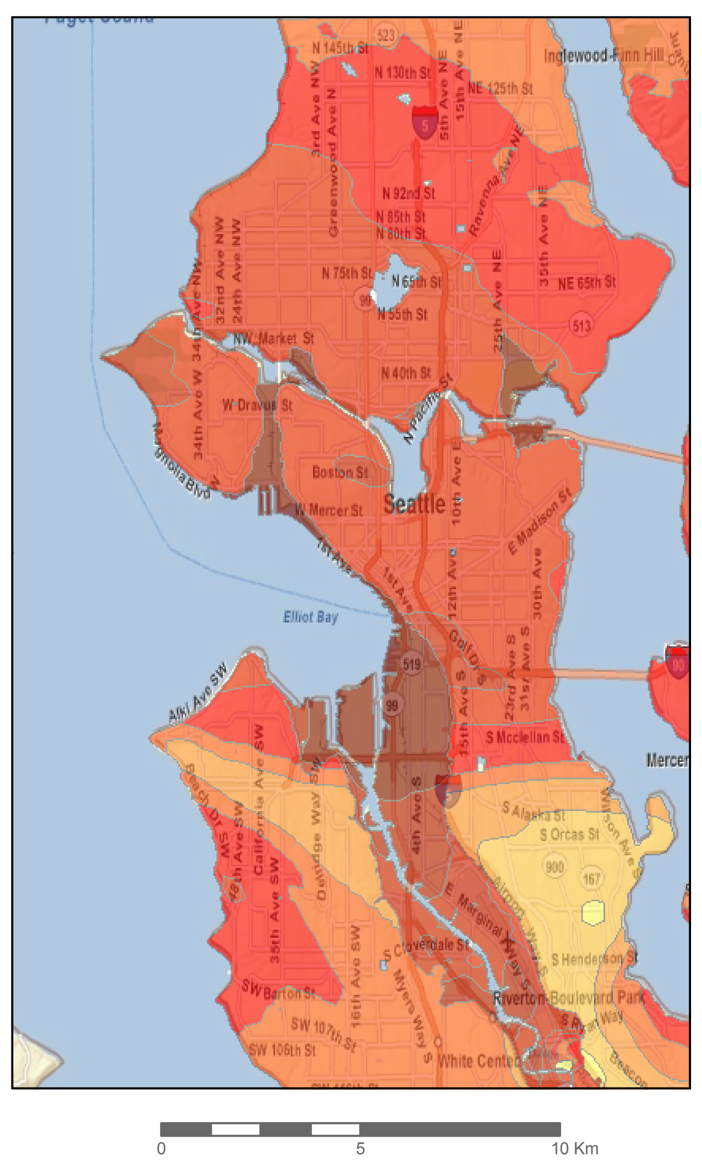


Overall, the population in this region resides in structures that are a mix of vulnerable and earthquake resistant construction. On April 29, 1965 (UTC), a magnitude 6.5 earthquake occurred near the Puget Sound, Washington, region 53 km south of the location of this earthquake, with estimated population exposures of 131,000 at intensity VIII and 1,587,000 at intensity VII, resulting in an estimated 7 fatalities. Recent earthquakes in this area have caused, landslides and liquefaction that may have contributed to losses.

This information was automatically generated and has not been reviewed by a seismologist.

http://earthquake.usgs.gov/pager — Event ID: UW01301325

Seattle Urban Seismic Hazard Map 2007



1 Hz Spectral Acceleration with 2% Probability of Exceedance in 50 Years

%g
- 200-300
- 160-200
- 140-160
- 120-140
- 100-120
- 80-100
- 60-80
- 50-60
- 45-50

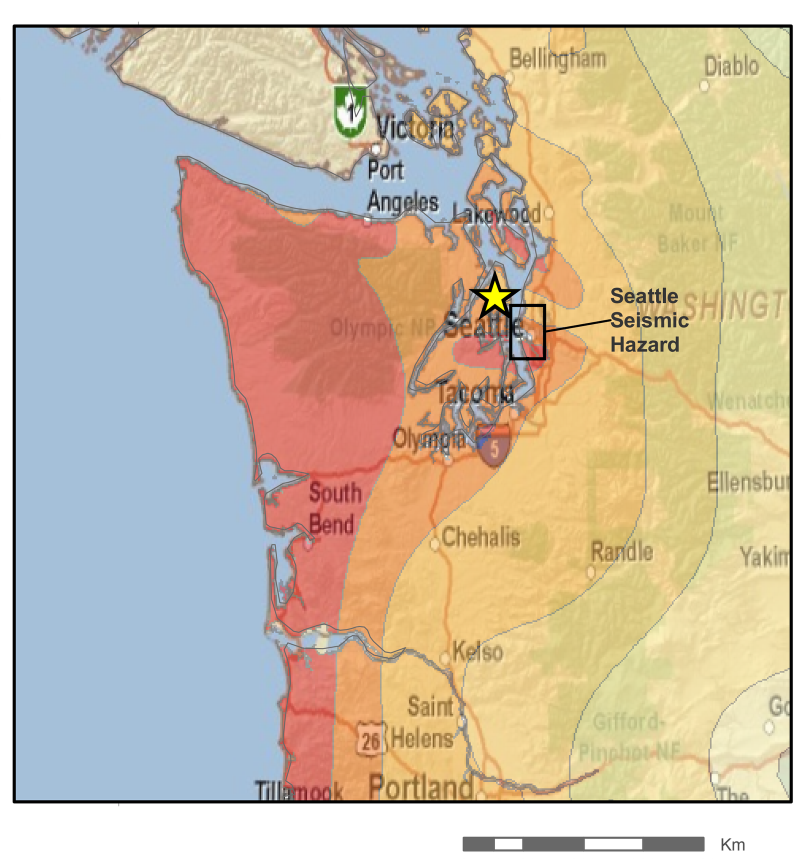
Seismic hazard maps convey forecasts of earthquake ground shaking levels expected to be exceeded with a 2% probability in a 50 year time period. Motions are measured in units of acceleration, or gravity (g). The maps account for all known earthquake sources and their occurrence likelihoods. National scale maps (right) assume the subsurface materials are uniform, whereas urban scale maps (above) account for variations in the rocks and sediments in the shallow layers that can amplify or damp out motions.

Seismic Hazard

Seismic Hazard 2% in 50 years

%g
- 160-200
- 120-160
- 80-120
- 60-80
- 50-60
- 40-50
- 30-40
- 20-30
- 18-20
- 16-18
- 14-16
- 12-14
- 10-12
- 8-10
- 6-8
- 4-6
- 2-4
- 0-2

US National Seismic Hazard Map 2008



Tectonic Summary

The January 30, 2009 Mw=4.5 Kingston earthquake resulted from strike slip motion on a fault within the Juan de Fuca plate, which is subducting beneath North America. Intraplate earthquakes are one of the four earthquake types rumbling the Pacific Northwest. The other types are megathrust earthquakes that rupture the interface between subducting plates, crustal earthquakes that break shallow faults, and volcanic earthquakes that occur because of forces generated by moving magma.

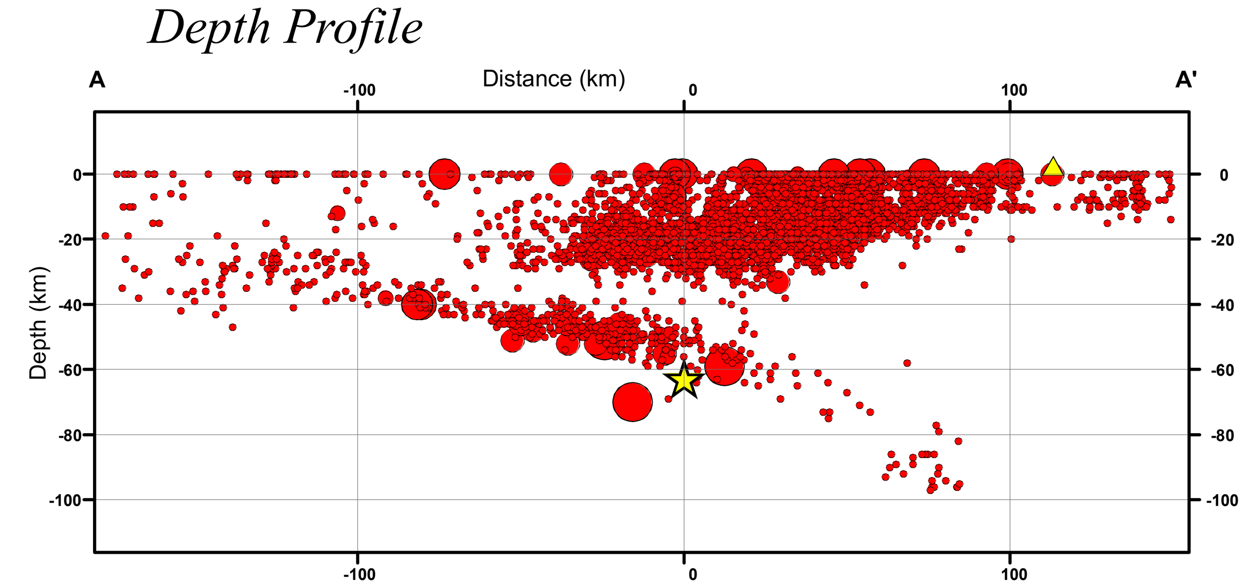
Intraplate earthquakes break faults within the downgoing Juan de Fuca plate. As the plate descends beneath North America, it bends, stretches and compresses, giving rise to earthquakes. Intraplate earthquakes are expected to be limited in size to about M7.2. While they may be large enough to cause damage, ground shaking from deep intraplate earthquakes is somewhat muted by the many miles of rock between the surface and the deep focus of energy release.

The Kingston earthquake was a strike-slip earthquake, with the relative motion of each side of the nearly vertical fault being horizontal. Other earthquakes in this class, such as the 2001 M6.5 Nisqually earthquake, have resulted from the failure of normal faults, where overlying rocks move downward along a fault that dips more gently.

For reasons that are not well understood at this time, earthquakes in the intraplate class give rise to extremely sparse aftershock sequences. Often they have no aftershocks at all. This contrasts with large shallow crustal earthquake that can have hundreds or even thousands of aftershocks.

The largest historical intraplate earthquakes in Cascadia include the 1949 (M7.1 "Olympia"), 1965 (M6.5 "Seattle"), and 2001 (M6.8 "Nisqually") earthquakes, all of which caused extensive damage in the region. The 1949 and 2001 earthquakes were located at the southern end of Puget Sound while the 1965 earthquake was deep beneath Sea-Tac. The Kingston earthquake was the largest earthquake of its class to occur in the northern Kitsap county area since the beginning of the modern era of seismic recording. The last similar earthquake was an M4.8 earthquake on April 25, 2003 that was 50 km deep about 50 km west of the Kingston earthquake, and caused similar ground shaking levels around the Puget Sound. The last earthquake of a similar magnitude in the Seattle region was a shallow, crustal, M4.5 event on October 7, 2006, 4 km deep, near Mt. Rainier. Current estimates of the likelihood of another potentially damaging intraplate earthquake during a 50-year time window with the Puget Sound region put the probability at about 84%, with somewhat lower probabilities as one goes southward.

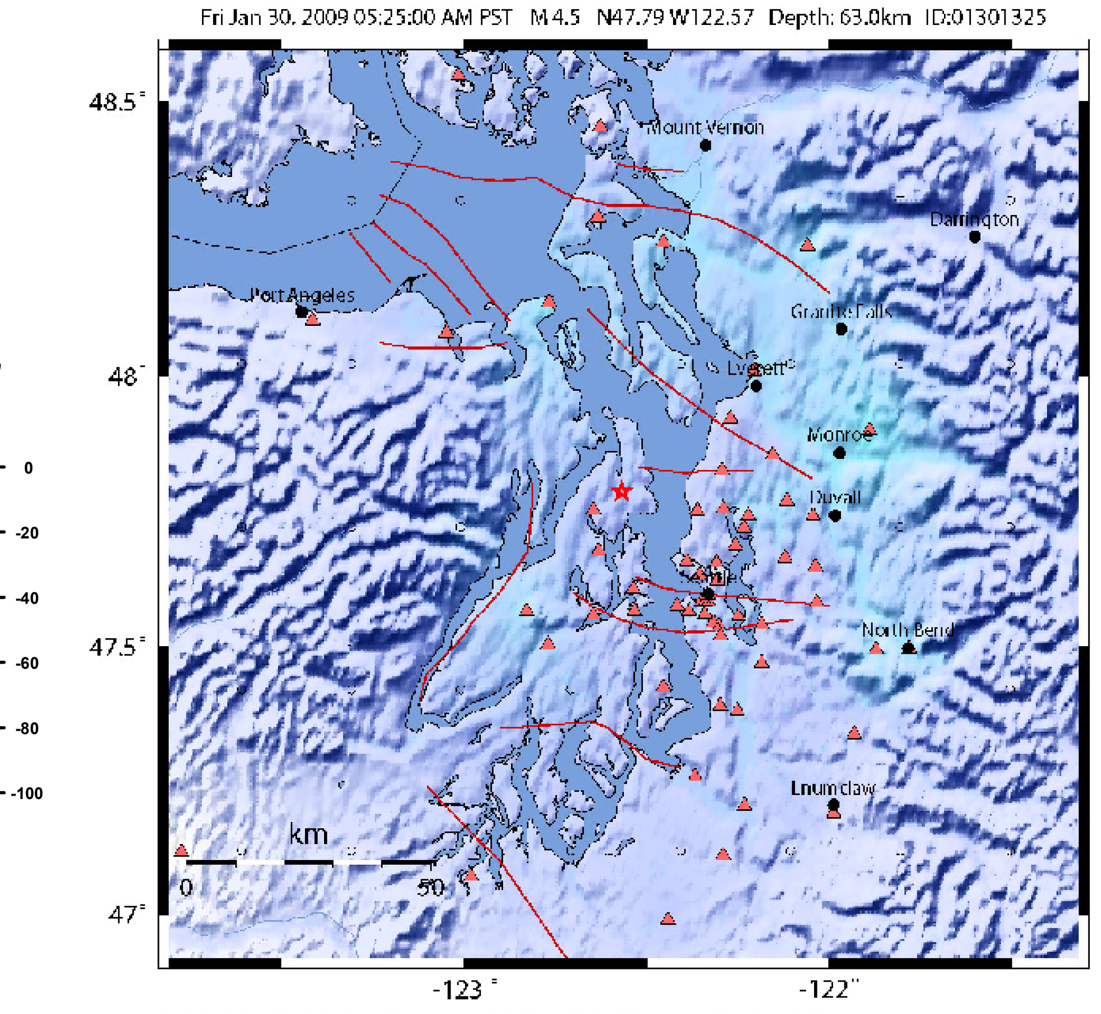
Depth Profile



Significant Earthquakes Mag >= 6.0

Year	Mon	Day	Time	Lat	Long	Dep	Mag
1872	12	15	0540	47.9	-120.3	0	7.0
1909	01	11	2344	49.000	-122.700	0	6.0
1949	04	13	1955	47.167	-122.617	70	6.9
1965	04	29	1528	47.400	-122.300	59	6.7

PNSN ShakeMap : 8.1 km NE of Poulsbo, WA
Fri Jan 30, 2009 05:25:00 AM PST M 4.5 N47.79 W122.57 Depth: 63.0km ID:01301325



Map Version 5 Processed Tue Feb 3, 2009 04:03:40 PM PST, -- NOT REVIEWED BY HUMAN

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+

ShakeMap is a product of the U.S. Geological Survey Earthquake Hazards Program in conjunction with regional seismic network operators. ShakeMap sites provide near-real-time maps of ground motion and shaking intensity following significant earthquakes.
Red triangles show station locations, red lines show known faults. Colors indicate predicted shaking level. The prediction for this earthquake was light shaking in eastern areas, and some light shaking in the Hood Canal area.

DATA SOURCES

EARTHQUAKES AND SEISMIC HAZARD
USGS, National Earthquake Information Center
ANSS, Advanced National Seismic System
NOAA, National Geophysical Data Center
IASPEI, Centennial Catalog (1900 - 1999) and extensions (Engdahl and Villaseñor, 2002)
HDF (unpublished earthquake catalog) (Engdahl, 2003)
Global Seismic Hazard Assessment Program
Pacific Northwest Seismic Network, University of Washington

PLATE TECTONICS AND FAULT MODEL
PB2002 (Bird, 2003)

BASE MAP
NIMA and ESRI, Digital Chart of the World
ESRI Online Services
USGS, EROS Data Center
NOAA GEBCO and GLOBE Elevation Models

REFERENCES

Bird, P., 2003, An updated digital model of plate boundaries: Geochem. Geophys. Geosyst., v. 4, no. 3, pp. 1027- 80.

Engdahl, E.R. and Villaseñor, A., 2002, Global Seismicity: 1900 - 1999, chap. 41 of Lee, W.H.K., and others,eds., International Earthquake and Engineering Seismology, Part A: New York, N.Y., Elsevier Academeic Press, 932 p.

Engdahl, E.R., Van der Hilst, R.D., and Buland, R.P., 1998, Global teleseismic earthquake relocation with improved travel times and procedures for depth determination: Bull. Seism. Soc. Amer., v. 88, p. 722-743.

DISCLAIMER
Base map data, such as place names and political boundaries, are the best available but may not be current or may contain inaccuracies and therefore should not be regarded as having official significance.

Map prepared by U.S. Geological Survey
National Earthquake Information Center
24 March 2009
Map not approved for release by Director USGS
http://earthquake.usgs.gov/