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Map of Selected Earthquakes for Oregon, 1841 through 2002

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Map of Selected Earthquakes for Oregon, 1841 through 2002

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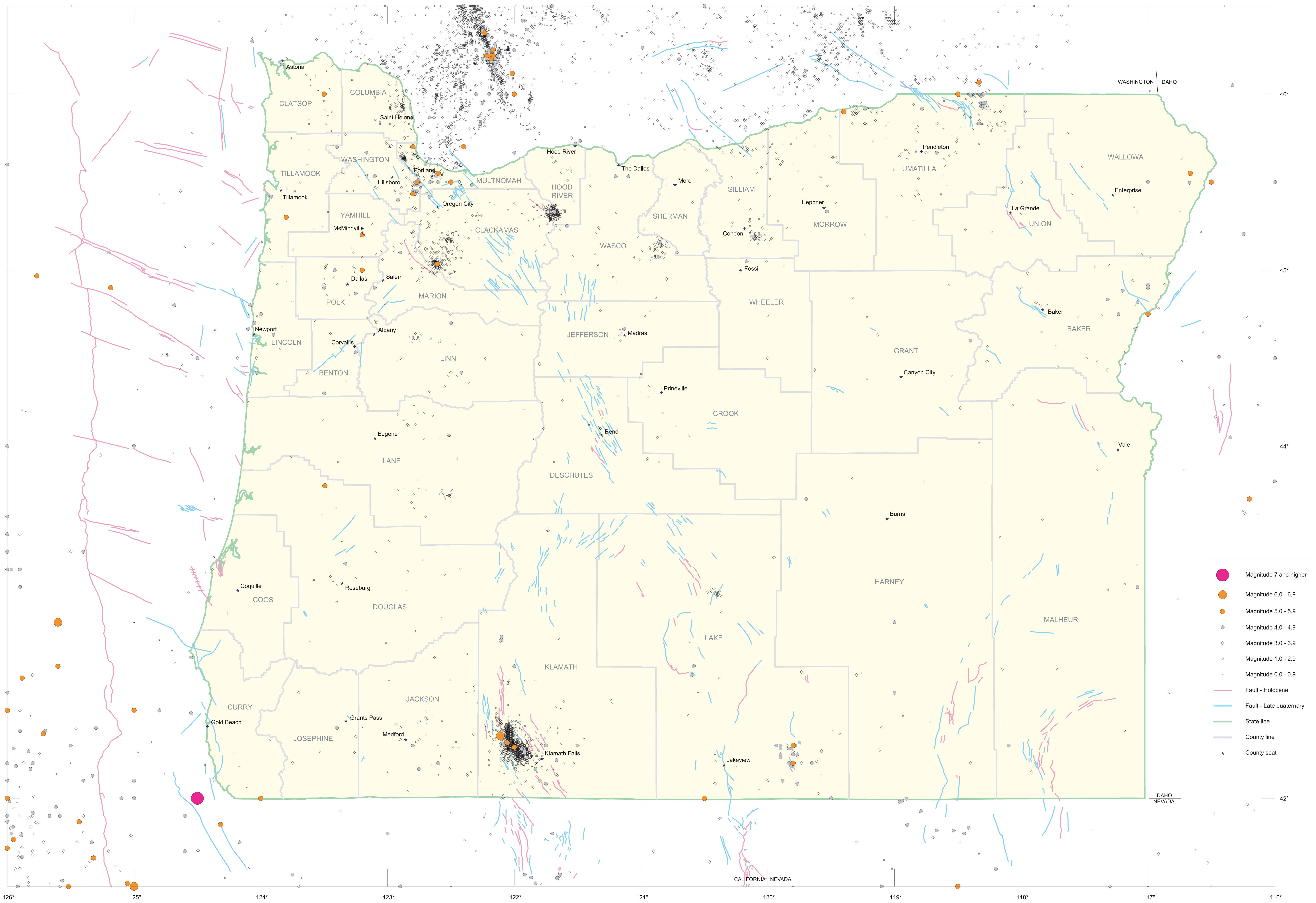

WHAT DOES THE MAP SHOW?

This map shows over 14,000 known earthquakes from 1841 to 2002. The Table to the right is a summary of major quakes that have affected Oregon, causing ground shaking and damage (Wang and Clark, 1999). It shows that Oregonians face injury and property damage from earthquakes originating throughout the Pacific Northwest. For this reason, the Oregon Department of Geology and Mineral Resources produced this map of the epicenters of historic earthquakes in Oregon, off the coast, and along Oregon's border with southern Washington and northern California. Historic patterns show areas in Oregon that are especially vulnerable to earthquakes.

The earthquake dataset for this map was compiled from two sources: the Oregon Department of Geology and Mineral Resources' Earthquake Database for Oregon (Johnson and others, 1994) and data from the Pacific Northwest Seismograph Network (PNSN) at the University of Washington Geophysics Department. You can view and retrieve earthquake data in PNSN's earthquake catalog from the following website:

http://www.geophys.washington.edu/SEIS/PNSN/CATDAT/welcome.html.

Johnson and others' (1994) dataset covered the area shown on this map. However, PNSN's current earthquake catalog contains records for earthquakes located between -125° and -117° longitude and 42° and 49° latitude. Earthquakes outside PNSN's coverage are recorders older than October of 1993. A remaining task in preparing a comprehensive earthquake map for Oregon is to incorporate data from other earthquake catalogs, particularly those that cover extreme eastern and southeastern Oregon. Also, the magnitudes of some earthquakes before 1962, roughly 250 events, were determined using intensity data (Jacobson, 1986). Data of this kind are not always precisely accurate. The data reflects poorly determined locations or magnitudes, and are often incomplete.

Earthquake epicenters are displayed on this map as diamonds and circles. These symbols are plotted at different sizes so as to provide a scale. Filled diamonds correspond to an earthquake with a magnitude between 0 and 0.9. Open diamonds represent earthquakes with magnitudes between 0.9 and 3.9. The colored circles represent larger magnitude earthquakes, those over 3.9. A legend explaining these symbols is shown in the lower right margin of the map.

The blackened areas on the map are the concentration of many symbols. This clustering is a result of earthquake activity that occurs in swarms. The largest earthquake in a swarm is the mainshock, sometimes preceded by foreshocks, and almost always followed by aftershocks. Also, within one cluster, there could be many earthquake swarms.

Geologically active faults are shown on this map (Geomatrix Consultants, 1995). Active faults are defined as those that moved in the last 780,000 years. Faults active in the last 20,000 years are color-coded red. Faults that moved between 20,000 and 780,000 years are color-coded blue. A less-than-straightforward connection between earthquakes and active faults exist in Oregon. The uncertainties in earthquake locations can be large and not all faults are known. Often this uncertainty makes it difficult to associate an earthquake with a particular fault.

Seismicity Patterns
We can make some general observations regarding the seismicity patterns shown on this map. Overall, earthquakes in Oregon are associated with four zones of seismicity: the Cascade seismic zone, Portland Hills (Portland-Vancouver metropolitan area), south-central (Klamath Falls), and northeastern Oregon.

Cascade
The earthquakes in the Cascade seismic zone are part of the Cascade Range of Washington, Oregon, and California, an active volcanic mountain chain where magma ascends into the crust because of the underlying subduction processes. The portion of the Cascade seismic zone in southwestern Washington contains the earthquake (magnitude 5.1) triggering the major lateral blast that ripped away the northern side of the Mount St. Helens volcano. The blast probably happened 20 to 30 seconds after the earthquake began. Approximately 440 earthquakes were associated with the 1980 eruption of Mount St. Helens.

In a typical year, one to several, short-lived swarms of small earthquakes are recorded on the south flake and below the summit of Mount Hood volcano in Oregon. These swarms probably represents a reaction to regional tectonic stresses, not pre-eruption volcanic activity.

Portland Hills
A scattered, northwest-trending cluster of earthquakes, called the Portland Hills seismicity zone, lies in the Portland-Vancouver metropolitan area (Blakely and others, 1995). Notable earthquakes in this zone included the 4.7 magnitude earthquake on November 7, 1961 and the November 5, 1962, earthquake of 5.5 magnitude. The Portland Hills seismicity zone is in a portion of northwestern Oregon sheared into a series of juxtaposed blocks moving in different directions.

Movement of the blocks induces earthquakes along northwest- and northeast-trending fault zones. Two have particular significance: the north northwest-trending Portland Hills and the Mount Angel-Gales Creek fault zones. The Portland Hills fault can be traced through downtown Portland and the fault may be a reason for the unusually steep scarp of Portland's West Hills. To the west, the Mount Angel-Gales Creek fault zone is a single, potentially active fault system that has been mapped from the Cascades into the Willamette Valley through to the Coast Range (Dougherty and Trehu, 2002). The 5.6 magnitude March 25, 1993, Scotts Mills (near Silverton and Woodburn in Marion County, Oregon) earthquake with an epicenter near Mount Angel, in Marion County, Oregon, may be associated with this fault zone (Madin and others, 1993). Other active faults in the Willamette Valley, no less significant, can produce future earthquakes as well.

South-Central Oregon
The dense cluster of earthquakes in south-central Oregon is associated with the September 20, 1993, earthquakes of 5.9 and 6.0 magnitude (Wiley and others, 1993). Aftershocks as large as magnitude 5.1 continued to disturb residents for six months (Sherrod and others, 1997). Epicenters for these earthquakes are near north- to northwest-trending faults about 19 miles northwest of Klamath Falls. Quakes in this area are related to the northernmost part of the Basin and Range geologic province, a vast area extending from south-central Oregon to Arizona and encompassing most of Nevada. The Basin and Range in south-central Oregon is stretching in an east-west direction causing the crust to break into blocks along steeply dipping faults (Wong and Bott, 1995; Wells and others, 1998). Earthquakes such as those near Klamath Falls and the earthquake swarm near the town of Adel (magnitude 5.1) to the east of Lakeview were probably triggered as the crust broke along existing faults.

Northeastern Oregon
In northeastern Oregon, several diffuse areas of seismicity fall on the Oregon-Washington border. The area near Milton-Freewater was the site of the 1936 magnitude 6.4 earthquake. This earthquake and the scattered seismicity in the region are related to the Olympic-Wallowa lineament. The lineament is a broad zone of northwest-trending faults and intervening basins and uplifts stretching from the Olympic Mountains of western Washington across the Cascades and Columbia Basin into the northeast side of the Wallowa Mountains in northeastern Oregon.

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Historical Earthquakes affecting Oregon

Date	Location	Magnitude	Comments
Approximate years 1400 BCE 1050 BCE 600 BCE 400, 750, 900	Offshore, Cascadia subduction zone[1]	Probably 8-9	Researchers Brian Atwater and Eileen Hemphill-Haley have dated earthquakes and tsunamis at Willapa Bay, Washington; these are the midpoints of the age range for these six events.
January 26, 1700	Offshore, Cascadia subduction zone[1]	Approximately 9	Generated a tsunami that struck Oregon, Washington and Japan; destroyed Native American villages along the coast.
November 23, 1873	Oregon/Califormia border, near Brookings	6.8	Felt as far away as Portland and San Francisco; may have been an intraplate event because of lack of aftershocks.
July 15, 1936	Milton-Freewater	6.4	Two foreshocks and many aftershocks felt; $100,000 damage (in 1936 dollars).
April 13, 1949	Olympia, Washington[1]	7.1	Eight deaths and $25 million damage (in 1949 dollars); cracked plaster, other minor damage in northwest Oregon.
November 5, 1962	Portland/Vancouver	5.5	Shaking lasted up to 30 seconds; chimneys cracked, windows broke, furniture moved.
1968	Adel	5.1	Swarm lasted May through July, decreasing in intensity; increased flow at a hot spring was reported.
April 12, 1976	Near Maupin	4.8	Sounds described as distant thunder, sonic booms, and strong wind.
April 25, 1992	Cape Mendocino, California[1]	7.0	Subduction earthquake at the triple-junction of the Cascadia subduction zone and the San Andreas and Mendocino faults.
March 25, 1993	Scotts Mill	5.6	On Mount Angel-Gales Creek fault; $30 million damage, including Molalla High School and Mount Angel church.
September 20, 1993	Klamath Falls	5.9 and 6.0	Two deaths, $10 million damage, including county courthouse; rockfalls induced by ground motion.
February 28, 2001	Near Olympia Washington[1]	6.8	About 400 injuries, $2 to 3.9 billion damage in the Seattle/Tacoma area. Felt area: Vancouver BC, Northwest Oregon, Salt Lake City UT.

[1] not shown on the map

EARTHQUAKE TERMS

An earthquake is defined as the "perceptible trembling to violent shaking of the ground, produced by the sudden displacement of rocks below the Earth's surface." Rocks respond to stress (being squeezed or pulled apart) near the Earth's surface by breaking. Where the rocks break and move, we call it a fault. The buildup of tectonic forces and release of stress on individual faults is what causes quakes. Higher stresses lead to larger earthquakes.

The earthquake's epicenter is the position on the Earth's surface directly above the focus of the earthquake. The focus is the location within the Earth where underground rock moves and sends out earthquake energy waves. We feel these waves as ground shaking. Earthquakes produce three main types of energy waves: P-waves (push-pull waves), S-waves (side-to-side waves), and L-waves (surface waves). Each radiates from the earthquake focus through the Earth at different rates. The distribution of earthquakes over time is known as seismicity.

The energy released from the earthquake is a basic quantity scientists have measured for more than fifty years. This energy release, or magnitude, is measured on the familiar Richter scale, invented by Charles F. Richter in 1934. Scientists calculate the magnitude of the earthquake from the largest seismic wave or vibration, and a seismograph records the vibrations (seismogram) that an earthquake makes. Earthquakes with a magnitude of about 2 or less are usually called microquakes. They are not usually felt and are generally recorded only on local seismographs. Magnitude 3 and 4 earthquakes are commonly felt, but rarely cause damage. Damaging ground shaking can accompany a magnitude 5 or 6 event, and major damage commonly occurs from earthquakes of magnitude 7 and greater. The Richter scale has no upper limit. Recently, another scale called the moment magnitude scale has been devised for more precise study of seismic activity. Moment magnitude is generally used now to describe earthquakes, but the categories are about the same.

Earthquake intensity is not the same as Richter's earthquake magnitude. They are frequently confused in media reports. Earthquake intensity describes the strength of shaking at a particular place, based on observations made of building damage. The intensity of an earthquake is expressed today as the Modified Mercalli Scale, devised in 1902 by Giuseppe Mercalli. The scale provides a series of idealized descriptions of the effects of an earthquake. Intensity 1 is imperceptible shaking. Intensity increases by steps to 10, which is total destruction. The intensity scale requires no instrumentation because any observer can make a classification. It provides a basis to estimate the size of historic earthquakes. Also, it is useful because an earthquake has only a single magnitude, but different intensities can be distributed throughout the affected area.

SOURCE OF EARTHQUAKES

Three sources cause earthquakes in Oregon (Mabey and others, 1993). First, shallow earthquakes (depths of 0-10 miles) occur on active faults in the crust. Second, deeper earthquakes (depths of 10-31 miles) are associated with the subducting Juan de Fuca plate. Third, deep earthquakes (depths of 31-62 miles) happen where the continental crust and ocean floor plates are locked against each other and periodically snap loose.

The Juan de Fuca plate is a slab of ocean floor moving eastward from the Juan de Fuca Ridge, which is about 300 miles off the coastline of Oregon and Washington. The term Cascadia subduction zone was given to the part of the plate that has descended beneath the westbound continental crust of western Oregon. Earthquakes can be very large in the subduction zone and often produce damaging tsunamis. The last great Cascadia subduction zone earthquake happened off the coast of Oregon and Washington in 1700, with an estimated magnitude of 9.0. Geological evidence indicates that huge subduction zone earthquakes have struck Oregon's coast every 300-800 years, with a record that extends back at least 11,000 years (Atwater and others, 1995; Atwater and Hemphill-Haley, 1997; Goldfinger, 1999). These earthquakes are not evenly spaced in time, and the calculated average intervals between events can be less or more. The Cascadia subduction zone is still continuing to creep and undoubtedly western Oregon will again experience the affects of a subduction-zone earthquake (Shedlock and Weaver, 1991).

The earthquakes shown on the above map were triggered within the Earth's crust at depths less than 25 miles (Jacobson, 1986). The largest of these earthquakes struck the coastline of Oregon and California near Brookings, Oregon, on November 23, 1873, with an estimated 6.8 magnitude. Wong (2002) suspects that this earthquake could be an exception and the quake was deeper within the descending Juan de Fuca plate.

This map is available from:
The Nature of the Northwest Information Center
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503/872-2750 www.naturenw.org
and the Baker City (541-523-3133) and Grants Pass (541-476-2496), Field Offices of the Oregon Department of Geology and Mineral Industries