STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
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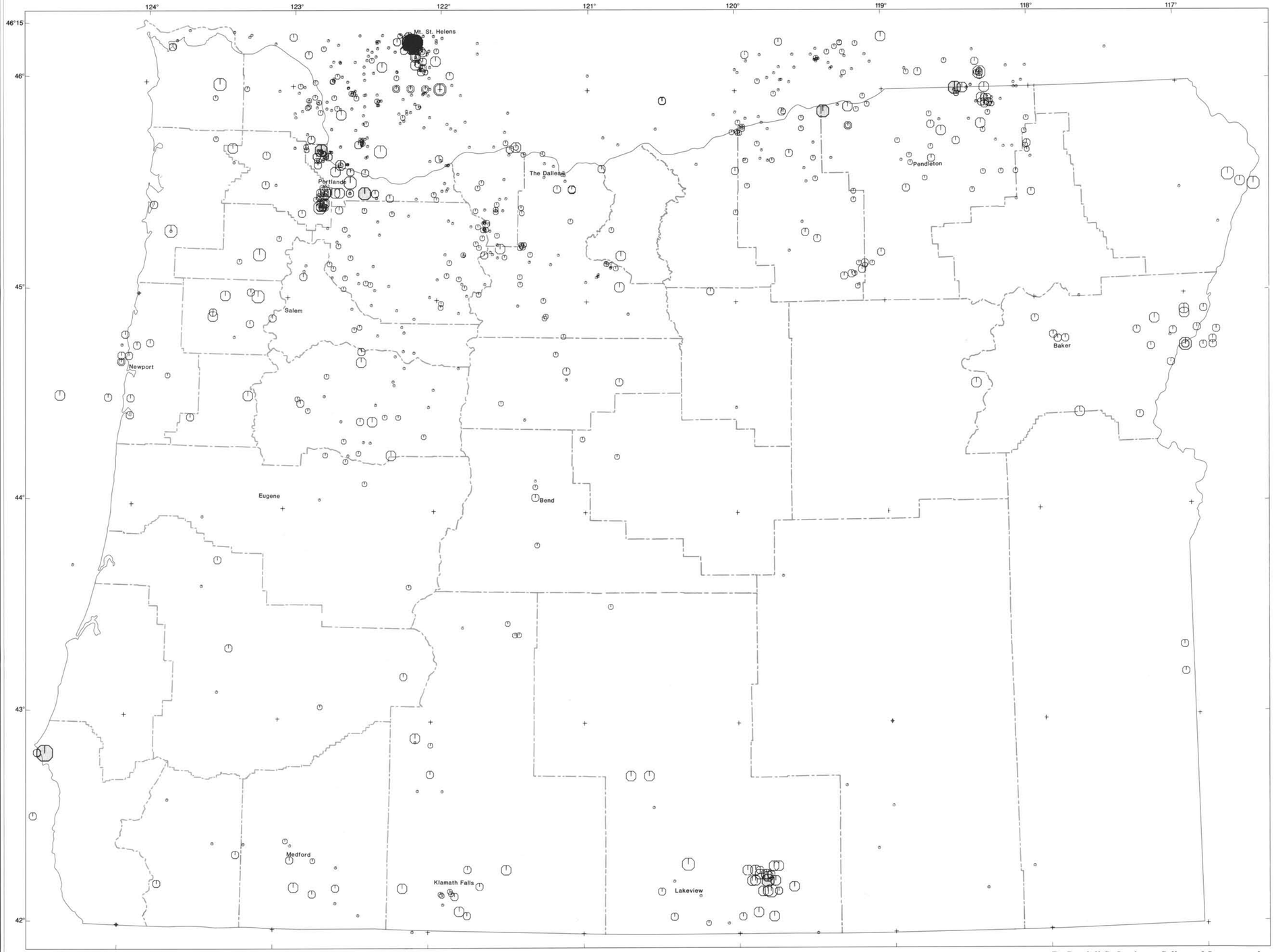
MAP OF OREGON SEISMICITY, 1841-1986

1986



Lambert conformal conic projection

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GMS-49

Map of Oregon Seismicity, 1841-1986

By R.S. Jacobson

DISCUSSION

Earthquakes are the result of sudden differential movement of the earth along fault planes. The specific location of the slippage is called the focus, or hypocenter, and the position on the earth's surface directly above the focus is called the epicenter.

To determine the size of an earthquake, seismologists now use the Richter magnitude scale, or similar closely related scales. The Richter magnitude is independent of the geology or instrumentation at the recording site. It relates the recorded ground motion, period, and distance to the epicenter to a single number, which approximates the size or energy release of the earthquake. The Richter scale is an open-ended logarithmic scale, with larger earthquakes having a larger numerical magnitude.

Each increase of a whole number in the Richter scale represents ten-fold increase in the amplitude of ground motion and an approximate 32-fold increase in energy. The scale was arbitrarily set so that an earthquake registering a 10 $^{+}$m ground motion at 100-km distance would have a magnitude of 0. The largest recorded earthquake is just under magnitude 9.0 on the Richter scale. The smallest earthquakes, called micro-earthquakes, have magnitudes less than zero.

The locations of nearly all of the events shown on this map that occurred prior to 1962 were determined by using intensity data. This measure of the size of an earthquake at a particular place is based upon the effect on people and structures and upon soil conditions. Generally, the intensity of an earthquake decreases with distance from the epicenter, so that intensity data can be used to constrain the epicentral position. Since intensity data depend critically upon human habitation, many of the older earthquakes are detected and located in and near population centers. Intensity data from the modified Mercalli scale can be related to the Richter scale to determine magnitudes by the use of empirical equations (e.g., Couch and Lowell, 1971). The errors in location of such events can be very large, up to 50 km.

With the advent of modern instrumentation, the ability to record and thus locate the epicenters of earthquakes has increased tremendously. Locational errors are typically 2 km for well-recorded earthquakes and about 10 km for very small earthquakes. The quality of hypocentral locations depends critically on the number of recording stations and the adequacy of knowledge of the crustal velocity structure used to calculate the travel times for the seismic waves as they are recorded at these stations. Thus, small earthquakes cannot be located, as they are recorded at only one or two recording stations (seismographs). The present instrumental coverage of Oregon is inadequate to locate all earthquakes that occur within the state. It is believed, however, that all earthquakes having magnitudes greater than 3.5 have been adequately recorded and located within Oregon.

This seismicity map of Oregon depicts all known earthquakes that have occurred in Oregon (and southern Washington) from 1841 to the present, as included in the unpublished Oregon State University Seismic Catalog, which is kept at Oregon State University. A total of 1,286 events are included. Of these, approximately 440 earthquakes were associated with the eruption of Mount St. Helens in 1980. Roughly 250 events occurred before 1962, at which time modern instrumentation able to record earthquakes more accurately became available.

All earthquakes shown in this map have occurred within the earth's crust at depths less than 40 km. No earthquake within Oregon has been associated with any known active faults or lineations, owing to two basic factors: (1) the incomplete knowledge of active faults in Oregon, and (2) the large errors in epicentral location of the earthquakes. Several clusters of known earthquakes have occurred within or close to Oregon (the Portland region, Mount St. Helens, Milton-Freewater, the Oregon-Idaho border, and the Warner Lakes area). The rest of the state of Oregon appears to exhibit diffuse seismicity, due principally to (1) the lack of adequate instrumentation, (2) the sparsely distributed population, and (3) possibly a lack of significant earthquakes.

Table 1
SEVEN LARGEST EARTHQUAKES THAT OCCURRED IN OREGON BETWEEN 1841 AND 1986*

Date	Place	Magnitude
Nov. 23, 1873	Port Orford/Crescent City	6.3 (est.)
Oct. 12, 1877	Portland	5.7 (est.)
March 7, 1893	Umatilla	5.7 (est.)
May 13, 1916	Richland	5.7 (est.)
July 16, 1936	Milton-Freewater	5.8
Oct. 1, 1964	Sauvie Island	5.3
May 30, 1968	Adel/Warner Lakes	5.1

*Symbols for these earthquakes are shaded on the map.

Earthquakes that occur outside the state of Oregon may also cause significant ground shaking and damage within the state. The areas in this region with the greatest potential for large earthquakes to occur include the Puget Sound area, Mount St. Helens, and the Blanco Fracture Zone off the coast of Oregon.

Caution should be exercised in using this map alone to define earthquake hazards within Oregon because of (1) the poor location of most of these events, (2) the short duration of the historical record of earthquake activity, (3) the incompleteness of the historical record, and (4) the occurrence of significant earthquakes outside Oregon.

If one assumes that the existing historical record of earthquake activity is indicative of seismic hazards, then one should expect only moderately severe earthquakes will occur in the future. Existing building codes have been designed based upon this criterion, and damage should not be catastrophic. Recently, however, Heaton and Kanamori (1984) compared the Juan de Fuca subduction zone, located offshore of Oregon and Washington, with other subduction zones around the world. The Juan de Fuca Plate, which underlies the northeastern Pacific Ocean, is being underthrust, or subducted, beneath the North American continental margin. The Cascade volcanoes are one consequence of this subduction process. At all other active subduction zones in the world, very large destructive earthquakes usually accompany subduction. None of the known earthquakes within Oregon, however, has been caused by subduction, suggesting that the Pacific Northwest is anomalous with respect to other subduction zones. Heaton and Kanamori (1984) suggest that if the Juan de Fuca subduction zone is not anomalous, then a magnitude 8.3 earthquake should occur beneath the Coast Range. Other studies (Adams, 1985; Heaton and Hartzell, 1986) suggest a recurrence interval of 400 to 550 years for these great earthquakes in the Pacific Northwest. The historical record, covering only 150 years, is clearly too short to confirm or deny this hypothesis.

An alternative explanation for the lack of subduction-related seismicity in Oregon is that subduction is occuring aseismically; that is, subduction is taking place smoothly without any significant earthquake activity. If this latter hypothesis is correct, then the Juan de Fuca subduction zone would be unique in the world. This controversy has only recently been debated, and future research may help resolve which hypothesis is correct.

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EARTHQUAKE MAGNITUDES

1.0+
2.0+
3.0+
4.0+
5.0+
6.0+

Shading on symbol indicates one of seven largest earthquakes shown on map.

Scale 1:1,000,000

10 5 0 10 20 30 40 50 Miles

10 5 0 10 20 30 40 50 60 Kilometers