

= 1872 North Cascades earthquake =

The 1872 North Cascades earthquake occurred at 5 : 40 a.m. local time in northern Washington state on December 15 . A maximum Mercalli intensity of VIII (Severe) was assessed for several locations , though less intense shaking was observed at many other locations in Washington , Oregon , and British Columbia . Some of these intermediate outlying areas reported V (Moderate) to VII (Very strong) shaking , but intensities as high as IV (Light) were reported as far distant as Idaho and Montana . Due to the remote location of the mainshock and a series of strong aftershocks , damage to man made structures was limited to a few cabins close to the areas of the highest intensity .

Because the earthquake occurred before seismometers were operating in the region , the magnitude of the shock and its location were never precisely determined , but the intensity reports that are available for the event were studied , and various epicenters for the event were proposed based on these limited data . One study presented an estimated moment magnitude of 6 @. @ 5 ? 7 @. @ 0 , with a proposed location on the east side of the Cascade Range near Lake Chelan . The results of a separate study indicated that it may have been a larger event , placing the shock in the North Cascades , just south of the Canada ? United States border at Ross Lake .

= = Preface = =

The Cascadia subduction zone rarely influences the western portion of Washington state , but the November 1873 M7.3 shock near the California ? Oregon border may have been associated with it . Although activity in the Pacific Northwest (especially west of the Cascades in Washington) has occasionally been located near the subduction zone , earthquakes there (1949 Olympia , 1965 Puget Sound , 2001 Nisqually) have mostly been intraslab events . A large M7 earthquake on the Seattle Fault in 900 C.E. may have generated a tsunami in Puget Sound . The 1872 event east of the Cascades is not understood well due to the lack of instrumental records and reliable felt intensity reports .

= = Earthquake = =

As there were only six seismometers operating in Washington state and western British Columbia even as late as 1969 , there are insufficient instrumental records for older events in the region . Focal depths are unknown for shocks that occurred before that time , but seismologists Bakun et al. concluded that the event occurred on a shallow fault on the east side of the Cascade Range . They employed a method that was developed by W. H. Bakun and C. M. Wentworth for using earthquake intensity information that could be mapped to a corresponding moment magnitude . The intensities for twelve 20th @-@ century Pacific Northwest earthquakes were used for calibration before analyzing the known intensities for the 1872 event in an attempt to resolve the location and magnitude . The reports were interpreted in a way that placed the epicenter near the south end of Lake Chelan , but other considerations left other plausible focal points both north and northeast of the lake . The magnitude was estimated to be 6 @. @ 5 ? 7 @. @ 0 with 95 % confidence .

Using a similar strategy , S. D. Malone and S. Bor analyzed the known intensities for the 1872 shock , then compared intensity patterns for a number of instrumentally recorded earthquakes that also occurred in the Pacific Northwest . A factor that was taken into consideration was that for earthquakes that have either circular or slightly elliptical isoseismal maps , the epicenter is usually close to the center of the pattern , but that for shocks where instrumental information are also available , the epicenter is sometimes not where it would have been assumed to be , had only the intensity information (and no instrumental information) been available . An isoseismal map of the 1949 Olympia earthquake was presented as an example of a distorted or convoluted pattern that was attributed to local geological conditions that either attenuated or amplified the seismic waves , and it was emphasized that not taking into account these local features could lead to a misinterpretation of the felt intensities and to a misplaced epicenter .

Malone and Bor ran three simulations , with a projected M7.4 event occurring at a depth of 37 miles (60 km) , but took into consideration the differences in attenuation both east and west of the Cascades . Three exploratory locations were investigated , including the setting at the south end of Lake Chelan that reportedly had significant ground disturbances , their preferred location near Ross Lake , and a third location north of the Canada ? United States border that had been proposed much earlier by W. G. Milne . The Ross Lake site was chosen because it most closely matched their isoseismal pattern , but it was not strongly preferred over the Milne site , and the Lake Chelan location was excluded as being the epicenter , due to the regional attenuation characteristics that required a location further to the west . Several depths were investigated , but each had little impact on the isoseismal patterns below intensity VI , and since most northwest earthquakes occur between 25 ? 37 miles (40 ? 60 km) deep , they believe the shock was also near that depth , but did not dismiss the possibility that it was a shallower event .

= = = Damage = = =

Though the earthquake was felt over a very wide area (from the Pacific Ocean to Montana , and British Columbia to Oregon) the area that was most affected was largely unpopulated , and very few homes existed . A log building that was built on unconsolidated river sediment close to the mouth of the Wenatchee River had dislodged roof logs , and the kitchen became detached from the rest of the structure . Another log cabin between Entiat and Winesap also had roof damage . Mercalli intensities as high as VI (Strong) reached the western portion of the state , near the highly populated Puget Sound region , and to the southeast beyond where the Hanford nuclear reactor site later stood .

= = = Aftershocks = = =

A relationship exists between the depth of the mainshock and the occurrence of aftershocks , and several Pacific Northwest earthquakes illustrate this link , like the February 1981 M5.5 Elk Lake event in southwest Washington that was followed by more than 1 @,@ 000 in the first two years . The M7.3 1959 Hebgen Lake earthquake in Montana had a significant sequence of aftershocks , and the shallow M7 1983 Borah Peak event was followed by four aftershocks . In opposition , the intraslab events (and crustal shocks above the subduction zone) on the west side of the Cascades have had insignificant aftershock sequences , usually amounting to a minimal number of small aftershocks . For example , the 2001 Nisqually shock occurred nearly 18 @.@ 6 miles (30 km) deep and was followed by only four small aftershocks , and there was a similar procession for the 1946 Vancouver Island earthquake , a M7.6 crustal shock that also had a focal depth near 18 @.@ 6 miles (30 km) .

Aftershocks did follow the 1872 event , and during the initial 24 hours they were strong enough to be felt over a broad area , from Idaho and into southern British Columbia . The intensity of the shocks waned as time passed , and after a year they were still occurring , but were only being felt at Wenatchee , Lake Chelan , and Entiat . Bakun et al. listed the considerable aftershock sequence as a strong indication that the initial event was shallow .