

REEVALUATION OF PRE-1900 EARTHQUAKES IN WESTERN NEVADA
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ABSTRACT

Western Nevada has the highest earthquake hazard and seismic risk of the State. The urban corridor along the eastern Sierra Nevada Front is home to the second largest metropolitan area in the State, including Reno and the state capitol, Carson City. This area also has some of the highest activity faults in the state, high rates of background earthquake activity, relatively high rates of geodetically measured deformation, and a number of notable, major historical earthquakes, several of which were in the 19th century. These early earthquakes caused significant damage to the urban corridor and would be major events and potentially disasters if they occurred today. We are examining these pre-1900 earthquakes in detail to gain information about strong shaking in the Reno-Carson City urban corridor that can be used to help characterize seismic hazard potential, and to use the details of these events to motivate citizens and decision makers that the local earthquake threat is real and preparedness and mitigative actions are worthwhile.

This study began by canvassing and collecting descriptions of the pre-1900 earthquakes, including sending letters of inquiry, and contacting regional museums and libraries. We transcribed 212 accounts that we were able to locate for documentation and future research. There are some excellent accounts of collateral hazards, such as liquefaction and fire following earthquake, and other characterizations of these events are now possible, such as minimum economic losses. We have summarized these earthquakes and began an analysis of their most probable epicentral locations and magnitudes. This report provides a summary of each earthquake, a chronologic listing of the earthquake sequence, transcriptions of earthquake catalogs, newspapers, and journals, and a summary of the intensities reported. The analysis procedure and in-progress results are given in the final section.

The "1852? Earthquake" is here referred to as the "mid-1800s earthquake". We have no direct accounts of an earthquake during this period, but nonetheless it seems likely that a large earthquake occurred in the 1840s or early 1850s in western Nevada because there are so many recollections of such an event. Based on post-1900 earthquakes, it seems likely that such an event would be felt and noted by people in Sacramento, California, where "continuous records" were kept in the form of daily newspapers. We have been searching these records for any evidence of an earthquake in western Nevada and have found none in the year 1852, or the autumn months of 1850 and 1851 (there is a recollection that indicates the event occurred in the autumn, following the pine nut harvest). According to recollections, the event strongly shook the Pyramid Lake area, the Stillwater/Carson Sink area, or possibly both.

The effects of 1857 and 1860 earthquakes in Nevada are still poorly understood, largely because fires in Virginia City and San Francisco destroyed most of the records. These events shook large portions of the Sierra Nevada and northern California, so they were clearly major events. We have two recollections for the 1860 earthquake of possible near-field effects from the Pyramid Lake area (rockfalls and possible aftershocks) indicating that as a candidate location. Hope remains with continuing studies at the archives in Salt Lake City, Utah for diaries and letters for Nevada accounts for both of these events.

The effects of the 1868 and two major 1869 earthquakes are fairly well documented. These earthquakes severely shook the Virginia City-Steamboat area causing general hysteria amongst people. The 1868 event was limited to minor structural damage (bricks shaken down and brick walls cracked), whereas the 1869 events cracked many buildings, threw down parts of brick walls, and caused numerous rockfalls in the Virginia Range, along with large amounts of nonstructural damage. The accounts of the first 1869 event support the conclusion by Topozada and others (1981) that this event was centered further south than the Olinghouse area which has been traditionally ascribed the epicentral area; thus we feel labeling the 1869 earthquake as the "Olinghouse earthquake" to be erroneous. It has also been assumed that the first major 1869 earthquake was the largest. The accounts indicate that this may not have been the case, and that the second event was of equal size, or larger. With a lack of site conditions considered and using Topozada and others intensity assignments, the data are not yet good enough to gain a confidence in the general epicentral locations of these events yet using the Bakun and Wentworth (1997) approach.

The 1887 earthquake is one of the best documented and largest events of those studied, and caused several pronounced geologic effects, as well as damage. The earthquake notably shook western Nevada, the Sierra Nevada, and the central Great Valley. Whether any of the surface effects were the result of primary or secondary faulting remains a mystery; there is no confirmed surface faulting. Rockfalls, landslides, and liquefaction did occur, however. This earthquake was clearly the strongest earthquake in Carson City's history. Several buildings were severely cracked and large amounts of plaster fell. Delays in governance was limited to the clean up of fallen plaster, the caulking of cracks, and the restacking and counting of state money in the vault. Enough detailed information was collected for the 1887 event to make an estimate of the minimum economic loss of \$10,500 in 1887 currency. In-progress epicentral estimates using the Bakun and Wentworth (1997) approach indicate an epicentral area in the Lake Tahoe region; these results do not incorporate site corrections, although in general, the results with site corrections may not be dramatically different.

Less attention was given to the smaller events late in the 1800s (the 1888, 1894, 1896, and 1897 earthquakes). The maximum intensities for these events are estimated to be of Modified Mercalli Intensity VI to VII. Accounts are limited because of these events' small sizes. The events in 1888 were likely aftershocks of the 1887 earthquake. The 1894 earthquake sequence appeared to be localized in the Virginia City area; damage was nonstructural in nature. The 1896 earthquakes were part of a small, local sequence at Carson City with minimal nonstructural damage. The 1897 earthquakes rattled Virginia City and Carson City, causing some nonstructural damage and part of a brick wall to fail in Virginia City. In general, these events in

the late 1800s were not widely felt in western Nevada or eastern California.

To better characterize the sizes and locations of the larger and better documented pre-1900 earthquakes we applied the approach of Bakun and Wentworth (1998). To account for local conditions in western Nevada, we analyzed the larger post-1900 earthquakes to develop revised coefficients for equations used in the Bakun and Wentworth approach. To accomplish this we entered 3617 intensity estimates at 1090 sites from 27 earthquakes in Nevada and eastern California. Due to time constraints, we developed coefficients for estimates without site corrections. Not only do we need to conduct site analyses, but we have other earthquakes that can be added to the calibration data set.

We have developed preliminary estimates for the locations and magnitudes of the larger pre-1900 events, but we caution their use until site effects can be accounted for, upgrades of intensity values are incorporated, and further densification of intensity data occurs. All of these are planned in the next round of research.

It is interesting to note that although these earthquakes badly frightened people and caused damaged, they caused no hesitation in the determination and growth of western Nevada. We have found no accounts of death or serious injury, and major concerns were limited to re-establishment of business. If the 1869 or 1887 earthquakes occurred today, there would be much more structural and nonstructural damage because the exposure of risk to these earthquakes is so much greater.