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Report on Seismic Hazard at
the Sierran Sites Area.

By Perry Byerly.

To the Lawrence Radiation Laboratory
on March 3, 1964.

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Report on Seismic Hazard at the Sierran Sites Area

by Perry Byerly

Introduction

This report follows one of November 9, 1963, entitled "Report on Seismic Hazard at Camp Parks and Montezuma Sites". The "Introduction" in that report applies to this report and is repeated here.

In discussing earthquakes seismologists use two terms which confuse non-seismologists.

The older term is "intensity". It describes the effect of an earthquake on man and his works and on soil and rock. The modified Mercalli Scale of Intensity is shown in Table 1. Such effects depend on the reactions of people, on the nature (the soundness) of his structures, and the geological foundations, as well as on the distance from the source of the earthquake. The intensity can be modified by man if he is willing to build soundly on suitable geologic foundations. Piling when used on poorer geologic foundations has been found to have a very good effect.

The "magnitude" of an earthquake (usually referred to as the Richter magnitude, after its originator) is based on seismograms-- on the records written by seismographs. Originally it was defined as the logarithm (to the base ten) of the maximum amplitude (in millimeters) on the seismogram written by a Wood-Anderson seismograph

(of standard type) at a distance of 100 km. from the epicenter. By means of a nomogram Richter extended its use to Wood-Anderson seismograms recorded at other epicentral distances. Although other ways of computing magnitudes were later developed, the magnitudes as computed for this report are obtained from Richter's nomogram and Wood-Anderson seismograms.

In 1954 Gutenberg and Richter tried to get a relation between the magnitude, M , of an earthquake and its intensity at the epicenter I_0 . They gave $M = 1 + 2/3 I_0$.

There have been efforts to get a relationship between acceleration, a , and intensity I . In 1956 Hershberger came up with

$$\log a = 3/7 I - 9/10.$$

The above relationships involve gross approximations.

Table 1.

Modified Mercalli Intensity Scale of 1931

(abridged)

- I. Not felt except by a very few under specially favorable circumstances. (I Rossi-Forel scale).
- II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I and II Rossi-Forel scale).
- III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of truck. Duration estimated. (III Rossi-Forel scale.)

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- IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably. (IV to V Rossi-Forel scale.)
- V. Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel scale.)
- VI. Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel scale.)
- VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motorcars. (VIII Rossi-Forel scale.)
- VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed. (VIII+ to IX Rossi-Forel scale.)
- IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel scale.)
- X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel scale.)
- XI. Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into air.

"Modified Mercalli Intensity Scale of 1931", by Harry O. Wood and Frank Neumann, Bulletin of the Seismological Society of America, Vol. 12, No. 4, December 1931.

We must note that the accelerations used by Hershberger were those determined from strong motion seismographs. They are not due to static forces but to wave motion. Before the U.S. Coast and Geodetic Survey began its program of measuring "strong motion" in earthquakes (about 1930) we thought that an acceleration of one tenth of gravity would wreck cities. It was not so. Although Long Beach was considerably damaged in 1933, the city was not wrecked. Accelerations there were 0.3 gravity accompanying waves of periods 0.1 to 0.3 seconds which were repeated several times.

In studying the lists of earthquakes of the past we should remember a fundamental postulate of earth sciences: "The future will be like the past." We must not be led to reading into such lists any long term laws of change in the seismic habit of a region.

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Earthquake Hazard at Sierran Sites Area

I define the Sierran Sites Area as that between latitudes $38^{\circ}35'$ and $39^{\circ}N.$ and between longitudes 121° and $121^{\circ}25' W.$

Earthquakes Reported Felt in the Area

In the report on the Camp Parks and Montezuma Sites, I included only earthquakes reported for intensities greater than IV (windows and doors rattle, house creaks). In the case of the Sierran Sites there are only three earthquakes in the record which had an intensity over IV (these were V); I have included all earthquakes reported felt.

The following towns were selected for the study:

<u>Town</u>	<u>County</u>
Auburn*	Placer
Bowman	"
Clarksville	El Dorado
Folsom*	Sacramento
Lincoln*	Placer
Loomis*	Placer
Natoma*	Sacramento
Newcastle*	Placer
Penryn*	Placer
Represa*	Sacramento
Rocklin*	Placer
Roseville*	Placer
Sheridan*	Placer

Of these towns, those whose names are marked with an asterisk have sent in reports (felt or not felt).

The reports follow in Table 2.

Table 2.

- 1854, June 26, Placer County; two light shocks.
- 1875, December 23, Placer, Nevada and Yuba Counties.
- 1885, February 22, III at Newcastle, very slight.
- 1892, April 21, Newcastle, slight.
- 1898, March 30, felt in Auburn (earthquake destructive at Mare Island).
- 1906, April 18, slight shocks felt in Newcastle and Auburn; clocks stopped at Lincoln. (The great San Francisco earthquake.)
- 1932, December 20, IV at Roseville where hanging objects swung, III at Auburn (A Nevada earthquake)
- 1933, June 25:
- V at Lincoln where small objects moved.
 - V at Newcastle where vases and dishes were moved.
 - IV at Auburn where windows rattled and walls creaked.
 - IV at Roseville where windows rattled and hanging objects swung.
- 1940, February 8:
- IV at Sheridan where windows and dishes rattled and hanging objects swung; few were wakened.
 - IV at Loomis where windows and dishes rattled; few were

wakened.

IV at Penryn; same effects as at Loomis.

IV at Rocklin where windows rattled and frames creaked.

1948, December 29:

V at Sheridan where many were awakened and a few were frightened.

IV at Roseville where windows rattled slightly.

1950, December 14, V at Sheridan, rattled dishes, shifted sugar bowl.

1952, July 21, IV at Sheridan where windows rattled (the Tehachapi earthquake).

1954, July 6, IV at Auburn where house creaked (the first Fallon, Nevada, shock).

1954, August 23, V at Roseville where all were awakened (the second Fallon shock).

IV
1954, December 16, at Roseville where windows and dishes rattled (the Fairview Peak, Dixie Valley, Nevada, shock).

1954, December 21, IV at Auburn where windows rattled (a Humboldt County shock).

1959, April 1, IV at Auburn where windows, doors and dishes rattled, and house creaked (epicenter near Loyalton).

Reported not felt at Natoma, Penryn, Rocklin, and Roseville.

The record extends through 1962.

Several people have remarked to me that the city of Sacramento is frequently strongly affected by large Nevada earthquakes. This is quite true.

However the Sierran area under discussion is not so affected. There are numerous reports in the record of strong shaking in Sacramento accompanied by "not felt" reports from our area.

If one examines the isoseismal maps of the U. S. Coast and Geodetic Survey he will find shocks not listed in Table 2 above, in which our area is included in the felt zones--but looking into the reports he finds that none of our towns reported them although towns more distant from the epicenter did.

Epicenters Located in the Area.

Since 1941 the Bulletin of the Seismographic Stations of the University of California lists epicenters in northern California and Nevada with some detail.

A search of these Bulletins for 1941 through 1961 inclusive reveals only one in the selected area. This occurred on March 19, 1943, and was located at $38^{\circ}8$ North, $121^{\circ}1$ West. The magnitude of the shock was 3.9. However the location was rated "d" (out of a, b, c, d) or poor. In my study of the Camp Parks and Montezuma sites I excluded such.

The only good epicenter near the area, but not in it, occurred on October 15, 1960, at $39^{\circ}11'$ North, $121^{\circ}9'$ West (east of Marysville). The rating of the epicenter was b (good). The magnitude was 3.3.

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Conclusions.

The earthquake hazard at the Sierran Sites Area appears to be negligible. As far as intensities go, we might say four and a half is the greatest to expect, and get from Hershberger an acceleration of 10 cm/sec^2 .

Judging from the last twenty years, there is no reason to suspect active faults in the area; i.e. epicenters. This conclusion regarding active faulting is borne out by the record of felt earthquakes.

References.For Intensities.

Townley, S. D. and Allen, Maxwell W., "Descriptive Catalog of Earthquakes of the Pacific Coast of the United States, 1769 to 1928"

"Abstracts of Earthquake Reports for the Pacific Coast and Western Mountain Region", a quarterly issued by the U. S. Coast and Geodetic Survey.

"United States Earthquakes", an annual issued by the U. S. Coast and Geodetic Survey.

Hershberger, John, "A Comparison of Earthquake Accelerations with Intensity Ratings", Bull. Seismological Soc. America, Vol. 46, pp. 317-320, 1956.

For Epicenters.

"Bulletin of the Seismographic Stations", issued by the University of California.

Tocher, Don, "Seismic History of the San Francisco Bay Region", California Division of Mines Special Report 57, 1959.