SEISMIC POTENTIAL IN THE WESTERN NEVADA/EASTERN CALIFORNIA REGION

by

A. S. Ryall[I], W. U. Savage[II], and C. J. Koizumi[II]

SYNOPSIS

Almost 1,000 earthquakes with Richter Magnitude greater than about 2 have been located in the western Nevada/eastern California region for the period 1970-71. In areas where large earthquakes have occurred during historic time, aftershock activity appears to decay exponentially, and to die out almost completely after about a century. The lack of seismic activity in areas with continuous, fresh-appearing prehistoric fault scarps suggests that the seismic "cycle" is at least several hundred years long. In other areas, the lack of large-scale faulting for hundreds or thousands of years, together with a currently high level of seismicity, is interpreted as indicating high potential for large earthquakes in the near future.

INTRODUCTION

During the historic period since about 1850, eleven earthquakes with Richter Magnitude M > 6 1/2 have occurred in the western Basin and Range province. One of these, the great Owens Valley earthquake of 1872 probably had M of about 8. Other great earthquakes in the region were: 1915, Pleasant Valley, M = 7 3/4; 1932, Cedar Mountains, M = 7 1/4; 1954, Fairview Peak, M = 7 1/4.

In this paper, we evaluate seismic potential in the western Basin and Range region, by comparing the current distribution of small earthquakes with locations of historic earthquakes and geologically recent faults. The method used is similar to that of Fedotov[(1)], in his investigation of space-time relationships of large earthquakes in the Kurile-Kamchatka region. In that work, Fedotov found that major earthquakes along the northwest Pacific boundary tend not to overlap, but rather to fill in gaps between focal zones of previous large earthquakes in the active belt. He also found the seismic "cycle" in the Kurile - Kamchatka region to be about 140 years long, with a buildup in activity in a given focal zone 15-20 years before a major earthquake. In a previous study, Ryall, et al.[(2)] concluded that within major earthquake belts in the

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[I] Professor of Seismology and Director, Seismological Laboratory, Mackay School of Mines, University of Nevada, Reno, Nevada, 89507.

[II] Graduate Student, Mackay School of Mines, University of Nevada, Reno, Nevada, 89507.

(1) Seismicheskoe Raionirovanie SSSR (Seismic Regionalization of the USSR), Izd. "Nauka", Moscow, 1968, 121-150.

(2) Bull. Seis. Soc. Amer., 56 (5), 1966, 1105-1135.

western U.S., gaps in the seismicity pattern are filled in by successive large earthquakes; however, they did not discuss the length of a cycle of activity for that region.

ANALYSIS AND RESULTS

Figure 1 shows epicenters of earthquakes with M greater than about 2 in the western Basin and Range province for 1970 and 1971; numbers on the figure refer to specific earthquake or fault zones. Currently, the most active area is zone 1, which includes the aftershock zones of earthquakes in 1954 at Rainbow Mountain, Fairview Peak and Dixie Valley. Within this area, epicenters are tightly clustered in two north-trending fault lines. Zone 2, near Mina, had almost as many events as zone 1 during 1970 and 1971, but they were scattered over a broad area rather than located on specific faults. Areas of moderate seismicity include zones 3, 4, and 5, respectively in the Northern Owens Valley, Fishlake Valley, and the Reno-Carson City area.

Several years ago, Slemmons[3] published a preliminary report on Pliocene and Quaternary faulting in the Basin and Range province, in which an attempt was made to categorize faults according to age. Comparison of his maps with Figure 1 leads to two observations: (1) over the last approximately 11,000 years, faulting has occurred over the entire northern part of Nevada, as well as in Owens Valley and Death Valley in southeast California; and (2) where faulting is indicated to be only barely prehistoric, with fresh, continuous fault scarps that reach 10-15 feet in height (zones 6-9, Figure 1), current seismic activity is almost completely lacking. This suggests that the return period, or "cycle" for a given focal zone is at least several centuries long.

On Figure 2 we have plotted the number of seismic events during 1970-71 for each of the zones that had major earthquakes in historic time (zones 1, 10, 11 and 12 on Figure 1). The figure clearly shows that the current rate of activity in each of these zones is a function of time after the appropriate main shock. From this, we conclude that earthquakes in these zones are aftershocks of large historic shocks. The figure also indicates that the aftershock sequence of a typical large Basin and Range earthquake decreases exponentially with time, and dies out completely after about a century.

Following Fedotov, we next looked for areas in the western Basin and Range where moderate to high seismicity, in an area without recent faulting, might be interpreted as the foreshock part of the seismic cycle. As Figure 1 shows, the entire Nevada region has minor seismic activity; four of the zones (2-5) have epicentral concentrations in areas where a lack of fresh fault scarps indicates that major earthquakes may not have occurred for at least several centuries.

The most prominent of these is zone 2, which is almost as active as

(3) <u>Jour. Geoscience, Osaka City University</u>, 10, 1967, 91-103.

the Fairview Peak aftershock zone to the north. This area, together with zone 3, fill a gap in the pattern of historic seismicity, between the focal zone of the 1932 Cedar Mountains earthquake to the east and that of the 1872 Owens Valley shock to the south. From this we conclude that zones 2 and 3 have relatively high potential for moderate to large earthquakes in the near future. In support of this conclusion, strain seismometer recordings at station MNN indicate that deformation in zone 2 may be partly due to fault creep (K. F. Priestley, personal communication), which would be related to a high level of tectonic stress.

Zone 4, on the southwest Nevada/southeast California border, is an area of moderate seismic activity along a well-developed range-front fault system. Earthquakes in that zone tend to occur in swarms or clusters, and the largest cluster during 1970 and 1971 had 32 events with $M > 2$.

Zone 5, in the Reno-Carson City area, had over 100 small earthquakes during the period considered, but these events were scattered over a broad region. When the epicenter map, Figure 1, is superimposed on a geologic map of the region, most of these earthquakes are seen to be located along major faults of the Sierra Nevada/Basin and Range boundary zone.

Finally, it should be pointed out that there are substantial differences in structural complexity, and in the mode of earthquake occurrence and distribution between these zones. Zones 2 and 3, for example, are in an area of complicated structure and physiography, while zones 4 and 5 contain major range-front fault systems. All of the four zones have had moderate earthquakes ($M = 5 - 6\ 1/4$) during this century; zone 4 has occasional swarms of earthquakes, with many events in the range $M = 4 - 5$. Within zones 2 and 3 the epicentral distribution is too scattered for the assignment of earthquakes to particular faults; in zone 4 earthquakes seem to occur along a single fault system; and in zone 5 epicenters fall on a number of major faults. While our results indicate that all of these zones have high seismic potential, the seismic history, geologic structure and current seismicity of each of them needs to be studied in detail to determine the maximum credible earthquake to be expected within that zone.

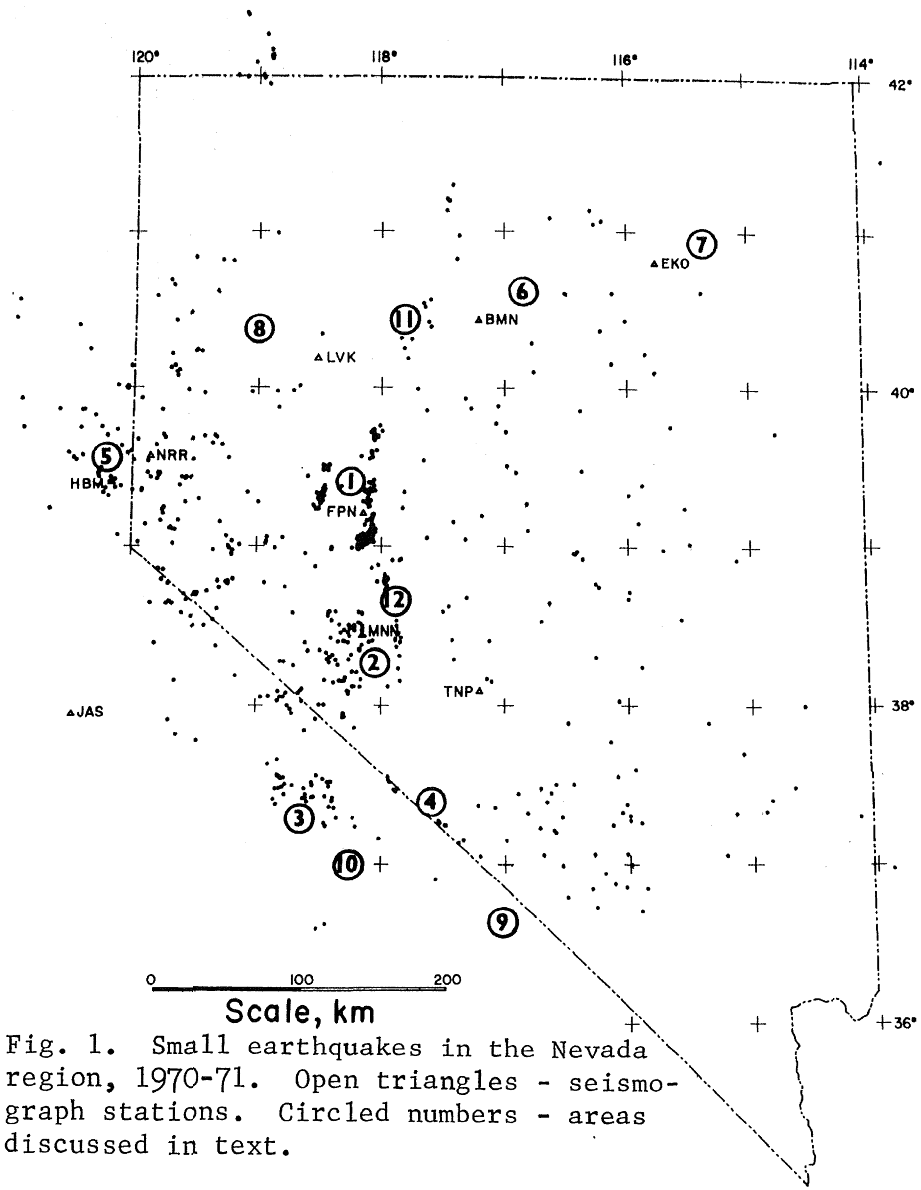

Fig. 1. Small earthquakes in the Nevada region, 1970-71. Open triangles - seismograph stations. Circled numbers - areas discussed in text.

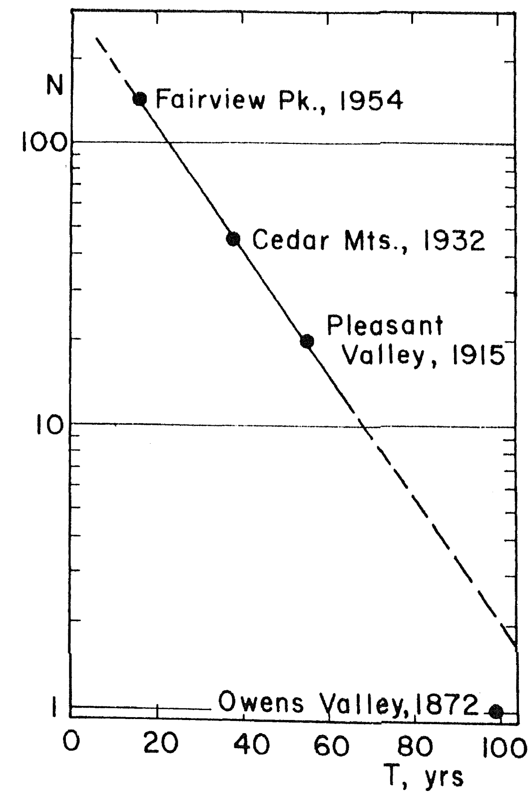

Fig. 2. Number of shocks vs. time after main shock, for zones with large historic earthquakes. N -- number of earthquakes located in zone during 1970-71. T -- time in years after main shock.