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Method of Study of Regional Seismicity

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A METHOD OF STUDY OF REGIONAL SEISMICITY

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One of the fundamental purposes of seismology is the prediction of the times of occurrence and the effects of earthquakes. Although a number of attempts at prediction have been made, most predictions have been inaccurate due to the lack of data on the causes of earth tremors. Attempts at predictions of times of occurrence have been particularly invalid.

In certain regions, however, data concerning the effects of earthquakes have been accumulating for many years, and these data may be used to set up criteria of damage which may be expected as a result of future earthquakes. Two such regions are the State of California and the Country of Japan; in both localities shocks are of frequent occurrence, and records of times of earthquakes and the accompanying damage have been kept for many decades. In these regions, past effects of earthquakes may be evaluated to give an estimate of future expected damage. One source of difficulty has been that the data has not been presented in a convenient form. This paper discusses a method of presentation of data which should be more useful than previous methods. Before describing the method, however, some classical concepts, definitions, and methods of presentation of data will be briefly reviewed.

Studies involving semi-statistical examination of various earthquake phenomena have led to the concept of the seismicity of a region. In general, the seismicity of a particular locality is considered to be measured by the frequency and intensity of earthquakes. California and Japan, as well as other regions, are considered to be quite seismic. The shield area of Brazil, on the other hand, is considered to be of low seismicity because few earthquakes occur there.

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There are two types of definitions of seismicity. Byerly (1942), for instance, has stated that a thorough rating of the seismicity should take account of the area shaken, the intensity of the shaking, and the frequency with which earthquakes occur. He defines the intensity of an earthquake as a measure of the damage done to structures built by man and changes in the earth's surface such as fissures in rock and disturbance of soil. The intensity rating is obtained through direct human observations of damage.

Gutenberg and Richter (1949, 1954), on the other hand, use instrumental data in their comprehensive study, Seismicity of the Earth. These instrumental data include epicentral locations, origin times, depths of focus, and magnitudes. The magnitude of an earthquake has purely physical significance in that it is defined by the equation

$$\log E = 11 + 1.6M$$

where M is the magnitude and E is the energy of the shock in ergs.

This writer is of the opinion that the term seismicity as it is commonly used means: (1) a measure of the frequency, maximum felt intensities, areal distribution of felt intensities, and areal distribution of the epicenters of earthquakes as determined by direct human observation, and (2) a measure of the frequency, magnitude, depth of focus, and areal distribution of epicenters of earthquakes as determined by instrumental methods.

The new method of study does not include all of the aspects outlined in the previous paragraph. It should be understood that the writer believes that a complete study of the seismicity of any region includes all of the above factors. However, this partial method is of immediate, practical value. The method simply consists of plotting the maximum intensity which has been felt at a particular geographic point on a base map of the region. The resulting distribution of the plotted intensity points in the region are "contoured" so that areas of equal intensity are included within a closed line.

To the general population, insurance underwriters, and construction engineers, the most important aspect of an earthquake is the maximum damage it causes. The usual question is: "What is the maximum extent of the damage that we can expect from the next earthquake which occurs here?" With such a map of a seismic region showing the maximum intensities that have been experienced in the past, the order of magnitude of intensities that can be expected are clearly shown.

Various scales of earthquake intensity have been erected in past years. The scale in common use in the United States is the Modified Mercalli Intensity Scale (1931) which contains twelve divisions of degrees of severity of the felt effects of earthquakes. Intensity IV, for example, is the rated intensity if the following effects are reported from a given locality:

> 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 motor cars rocked noticeably.

More damaging effects are given a higher intensity rating. For instance, Intensity VIII:

> Damage slight in specially designed structures; considerable in ordinary buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures; fall of chimneys, factory stacks, columns, monuments.

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In certain areas, after each occurrence of an earthquake, responsible governmental or private agencies may distribute questionnaires concerning the effects of earthquakes. The information thus collected from persons actually feeling the earthquake is then evaluated. After evaluation of each report, an intensity figure is assigned to each town, city, or other geographic point in the area of shaking. For a prominent earthquake these intensity figures may be plotted on a base map and "contoured." The resulting map is called an isoseismal map. Theoretically, the area of greatest intensity should correspond with the instrumentally determined epicenter of the earthquake, and such is usually the case. An hypothetical occurrence of an earthquake in Arkansas is given to illustrate a typical isoseismal map (Figure 1).

The writer has made a previous study, using the ideas described here, of the Western United States (Case, 1955). However, the study contained data only for the years 1934 through 1952. The study did serve to illustrate that the data of previous investigators could be plotted on base maps in the described manner. The resulting maps plainly showed areas of definite high seismicity in the west and areas of definite low seismicity. The study was quite insufficient, however, because the data from previous years was ignored. The procedure followed in the study is briefly outlined:

For each town, city, or other geographic point of sufficient importance to name, a card was prepared. On the card for a particular locality each earthquake intensity which had been recorded in past years was listed. A sample card reads:

Tacoma, Washington

Intensity	1934	1940	1944	1945	1946	1949	1950
I							
II							
III	1	1					
IV		1	2		1		
V				1	1	1	1
VI					1		
VII							
VIII						1	

The maximum felt intensity for Tacoma, Washington occurred in 1949 and was Intensity VIII. This was the figure which was plotted on the base map of Washington. A second feature of this method of listing of data is that frequencies of earthquakes or frequencies of occurrence of a given intensity can readily be seen. For instance, twelve earthquakes were felt in Tacoma from 1934 through 1952. More significant, perhaps, is the fact that as many as three earthquakes were felt in one year, 1946. On four occasions shocks of Intensity VI were felt. There are other statistical computations which can be made from this basic assemblage of data.

After the available data for a state has been assembled, the maximum felt intensities in each locality are plotted on a base map and lines enclosing areas of equal intensity are drawn. Figure 2 is an illustration from a previous paper of the State of Washington. The actual effect of this map is that it is a type of superimposed isoseismal map.

There are many limitations in this type of study. The most important is that certain areas have a sparse population and, commonly, few reports of earthquakes are received from such areas. Another limitation is that effects may be exaggerated by observers, or, conversely, may be diminished. The final limitation

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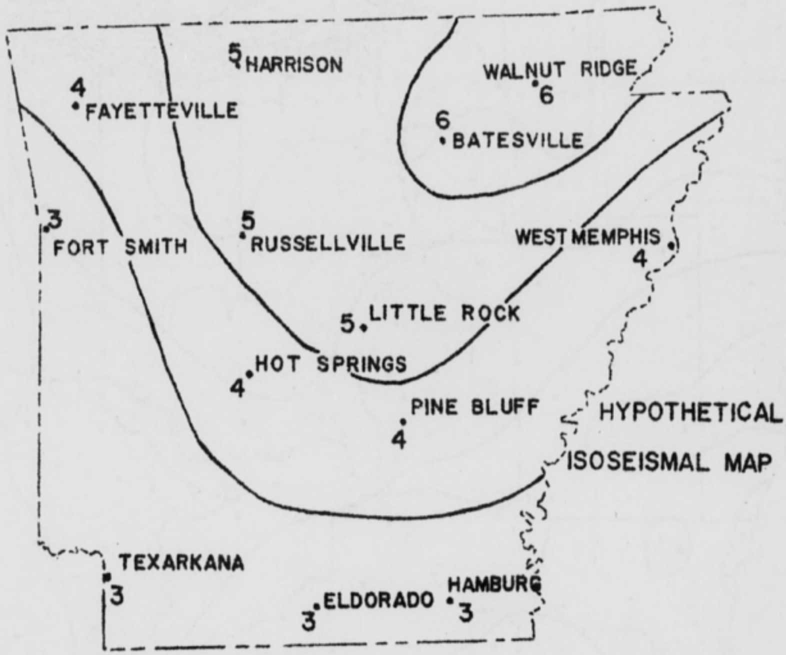

FIGURE I

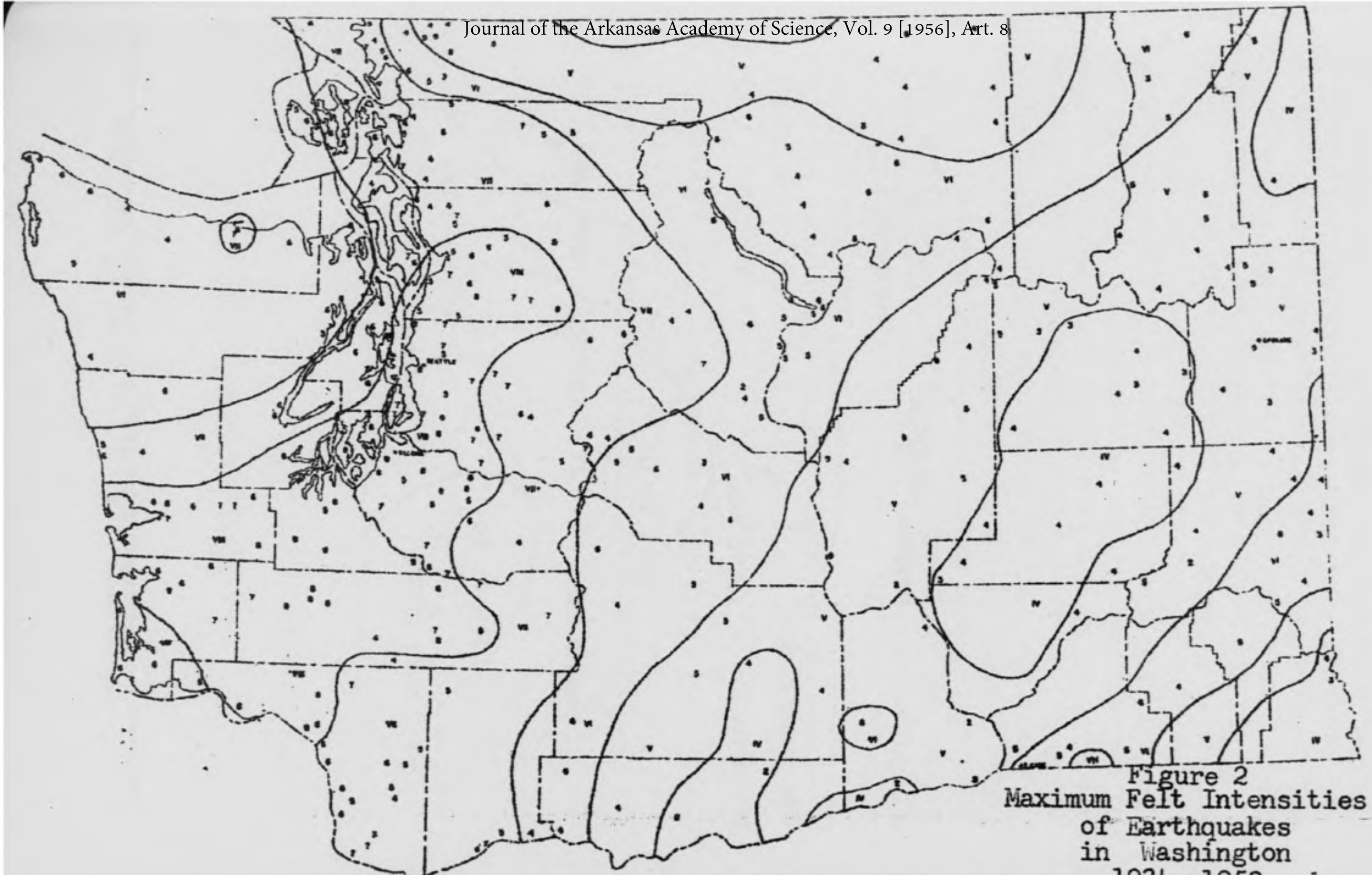

Figure 2
Maximum Felt Intensities
of Earthquakes
in Washington
1934—1952

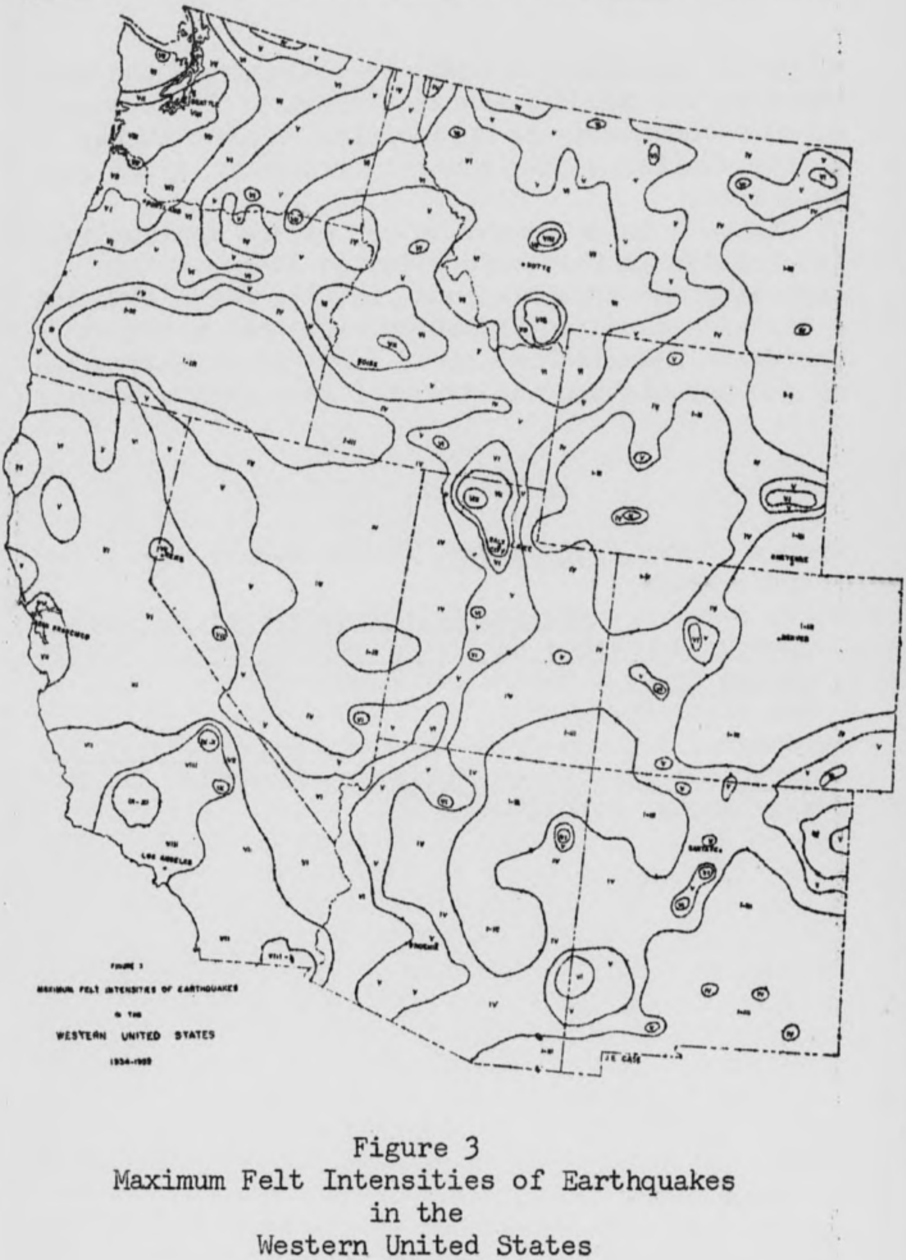

Figure 3
Maximum Felt Intensities of Earthquakes
in the
Western United States
1934-1952

of great importance is that the placement of the contours on the map is somewhat arbitrary. The accuracy of the contouring is a function of the number of points available for control, and many areas lack such data.

Figure 3 is a composite map of the maximum felt intensities in the Western United States. This illustrates the broad regional results of the study in a striking manner. It can be seen that attempts to correlate seismic high areas with particular types of geology might prove fruitful as a future study.

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