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EARTHQUAKE STUDY IN SOUTHERN CALIFORNIA, 1945

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This continues the previous report of GUTENBERG and RICHTER [see "References" at end of report, 1945 a]. Three papers reported as in press in 1945 have since appeared [GUTENBERG, 1945 a and b; GUTENBERG and RICHTER, 1945 b]. WOOD'S paper [pending] on local epicenters and fault structure in Southern California has been submitted to the Seismological Society of America.

As the first paper of GUTENBERG and RICHTER [1941] on seismicity of the Earth is now out of print, a revision has been undertaken, incorporating the results of the supplementary paper [GUTENBERG and RICHTER, 1945 b] and much new material. No epicenter has been accepted from the International Summary or any other source without careful revision. A large file of individual station bulletins has been accumulated through correspondence, as exchange or on loan. This has facilitated assigning magnitudes, and has much improved the statistics of large shocks. Magnitudes have been assigned to all shocks, shallow and deep, of magnitude 6 or larger, used in the study. For further statistical investigation the data have been entered on punch cards, which now number about 2500 for shallow earthquakes, and over 1000 for deep shocks. It is hoped that it will be possible to publish the full list of epicenters.

The largest shocks (1904 to 1945 inclusive) are shown in Table 1.

Table 1--Largest earthquake shocks, 1904 to 1945

Shallow shocks magnitudes near 8-1/2		Intermediate shocks magnitudes near 8			Deep shocks magnitudes 7-3/4 to 8		
Date	Location	Date	Location	Depth	Date	Location	Depth
				km			km
Jan. 31, 1906	Colombia	June 16, 1910	Loyalty Is.	100	Jan. 21, 1906	Japan	340
Aug. 17, 1906	Chile	June 15, 1911	Ryukyu	160	May 26, 1932	Tonga	600
Jan. 3, 1911	Tien Shan	Nov. 24, 1914	Marianas	110	Apr. 16, 1937	Tonga	400
Dec. 16, 1920	Kansu	June 26, 1926	Rhodes	100			
Mar. 2, 1933	Japan	Dec. 21, 1939	Celebes	150			

These shocks account for most of the release of energy in each group. The average annual energy release in units of 10^{26} ergs is about 10 for shallow shocks, 1.3 for intermediate shocks, and 0.3 for deep shocks. Although these figures may be in error by a factor 10, they are nevertheless comparable with the corresponding figures for energy transfer in secular internal cooling of the Earth, which is about one-tenth that for energy released in radioactive processes in the Earth's crust. Fluctuation is large; individual years range from 25 to 0.5 of the same units, with the exceptional year 1906 at 65. For shallow shocks the mean activity is roughly constant from 1904 through 1943. For deep shocks there is a decrease from about 0.5 to about 0.2 units in the same period. There are long intervals of relatively low activity in the intermediate depth range. For example, between October 19, 1929, and May 23, 1938, there was no intermediate shock with magnitude over 7.3.

The number of large shocks falls off rapidly with increasing depth to about 300 km; between 300 and 700 km the distribution in depth is fairly even, and then falls to zero abruptly.

For an increase by one unit of the magnitude, the frequency of occurrence decreases to about 1/8 for shallow shocks and about 1/13 for intermediate and deep shocks. For the largest shocks--above magnitudes of 8-1/4 in shallow shocks and above 7-3/4 in intermediate and deep shocks--the numbers decrease faster. On the average there are about 14 shocks annually of magnitude 7

or more, about 100 of magnitude 6 to 7 and (estimated) half a million of magnitude over 2. There are about four intermediate shocks and one deep shock annually of magnitude 7 or over.

For correlation with seismic data, JOHN M. NORDQUIST has compiled a list of active volcanoes from numerous sources. This is being verified and extended by correspondence.

The typical features and phenomena associated with active arcs of Pacific type [GUTENBERG and RICHTER, 1945 b, pp. 654-661] have been rediscussed. Further data are now available on the analogous but less active arcs of the trans-Asiatic Alpide belt, particularly in the Mediterranean area. Intermediate shocks occur in the belt principally under sharp flexures in the surface structures, and are frequently associated with active volcanoes and gravity anomalies.

B. GUTENBERG was placed under contract by the Navy Department as technical adviser and consultant for its project on the use of microseisms in hurricane detection [ORVILLE and GUTENBERG, 1946]. Among his unpublished findings is the result that microseisms are propagated only to relatively short distances in the Caribbean area, with rapid loss of energy in crossing the major structural discontinuities.

Study of seismograms for the New Mexico atomic bomb test of July 16, 1945, shows that Pn was recorded at Tucson, Palomar, and Riverside, with a velocity of 8.0 km/sec. Air waves of various velocities were recorded by seismographs at no less than ten stations.

A study of the larger California shocks for which instrumental records are available is being prepared by C. F. RICHTER and J. M. NORDQUIST.

A portable seismometer was dispatched into the area of the large shock of March 15, 1946. The records of aftershocks were valuable in locating the source of the main earthquake, which is tentatively placed at 35°44′ N, 118°02.5 W, with O = 13:49:36 U. T. (05:49:36 PST), and magnitude about 6.4.

Routine bulletins for teleseisms have been prepared through 1945; those for local shocks are in course of completion.

References

GUTENBERG, B., Amplitudes of P, PP and S and magnitude of shallow earthquakes, Bull. Seis. Soc. Amer., v. 35, pp. 57-69, 1945 a.

GUTENBERG, B., Magnitude determination for deep focus earthquakes, Bull. Seis. Soc. Amer., v. 35, pp. 117-130, 1945 b.

GUTENBERG, B., and RICHTER, C. F., Seismicity of the Earth, Special Paper no. 34, Geol. Soc. Amer., 1941.

GUTENBERG, B., and RICHTER, C. F., Earthquake study in Southern California, 1944, Trans. Amer. Geophys. Union, pp. 313-314, 1945 a.

GUTENBERG, B., and RICHTER, C. F., Seismicity of the Earth (supplementary paper), Bull. Geol. Soc. Amer., v. 56, pp. 603-668, 1945 b.

ORVILLE, H. T., and GUTENBERG, B., The use of microseisms in hurricane detection, Trans. Amer. Geophys. Union, v. 27, no. 1, pp. 111-117, 1946.

WOOD, H. O., Earthquakes in Southern California with geologic relations, to be published in Bulletin of the Seismological Society of America.

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