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The Mekran Earthquake of the 28th November 1945

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THE MEKRAN EARTHQUAKE OF THE 28th NOVEMBER 1945.

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Abstract.—This Note contains an account of the great Mekran Earthquake of the 28th November 1945. The seismic history of the area is outlined and the available seismometric data are summarised. The magnitude and the energy of the earthquake are calculated and it is found that, so far as the magnitude is concerned, this earthquake is not particularly important in comparison with other great earthquakes. The important feature of this earthquake is the seismic seawave associated with it. The available information regarding the effects of the seawave has been summarised. The isoseismal lines for the earthquake, based on field reports, are shown in a map and inferences are drawn from them. Additional information, especially about the two islets reported to have been thrown up by the earthquake, is given.

Introduction.

The object of this Note, which consists of six sections, is to give a brief account of the earthquake of 1945 November 28 which, with its epicentre under sea near the Mekran Coast, was attended by a disastrous seismic sea wave. Section 1 gives a sketch of the earthquake history of the region over which it was felt. Section 2 gives a summary of the available seismometric information. Section 3 gives the seismometric estimate of the magnitude and energy of the earthquake. Section 4 contains a map showing the isoseismal lines for the earthquake and the conclusions drawn from it. Section 5 contains an account of the seismic sea wave mentioned above. In section 6 is given some additional information regarding the shock.

1. The seismic history of the area of the Mekran earthquake.—The earthquake which shook the Mekran Coast, Baluchistan, Sind and parts of the Punjab in the early hours of the morning of the 28th November 1945 was by no means a rare event for that portion of the globe. Earthquakes have been known to occur in that area in the past, and we mention below some important ones.

1819 June 16	Cutch.
1892 December 20	Chaman, Baluchistan.
1909 October 21	Baluchistan (Kachhi).
1931 August 27	Mach, Baluchistan.
1935 May 31	Quetta.

During the last few years there have been some earthquakes having epicentres near the Mekran Coast and Karachi. Some of them are listed below :—

Time (G.M.T.)	Epicentre	
1938 February 4	25·5° N.,	Mekran Coast
00h. 19·0m.	63·5° E.	
1938 September 2		Ormara.
20h. 29·0m.		
1940 January 7	26·0° N.,	Near Mekran Coast.
09h. 1·9m.	63·0° E.	
1941 October 29	26·6° N.,	Baluchistan.
13h. 13m.	63·5° E.	
1942 July 3	24·5° N.,	Felt at Karachi.
02h. 50m. 30s.	65·5° E.	
1942 July 4	Near 25° N.,	Baluchistan.
08h. 46m. 20s.	67° E.	
1943 February 6	24·2° N.,	Near Pasni.
02h. 35m. 48s.	62·6°E.	

An increase in the seismic activity in this region is noticeable in recent years, since, according to the International Seismological Summary, there are only about half a dozen earthquakes with epicentres in this area, for the period 1913-34. This relative increase cannot and should not, however, be used to make a forecast of the earthquake activity in the region in the coming years.

2. A summary of the available seismometric data.—The earthquake of the 28th November 1945 was, as recorded by the seismographs throughout the world, one of great intensity. It is not possible to locate the different phases of the earthquake in the available Indian seismograms ; in the case of photographic records of Milne-Shaw seismographs, the traces were invisible for some time after the first impulse ; in the case of mechanically registering seismographs, the motions were so large and rapid that the onsets could not be marked with certainty and accuracy. The epicentre and the origin time of the earthquake have been determined from the times of the onsets of the P-phase at the different stations. The data are summarised below :—

Station	Time of commencement (G.M.T.)
Bombay	eP_N = 27d. 21h. 59m. 19s.
	iP_E^N = 27d. 21h. 59m. 20s.
New Delhi	iP_N = 27d. 21h. 59m. 54s.
	iP_E = 27d. 21h. 59m. 56s.
Calcutta	iP_E = 27d. 22h. 02m. 00s.
Hyderabad (Deccan)	iP_N = 27d. 22h. 00m. 31s.
Kodaikanal	iP_E = 27d. 22h. 01m. 19s.

Origin time : 27d. 21h. 56m. 40s. G.M.T. Epicentre : 24·2°N., 62·6° E. The epicentre is under sea near the Mekran Coast and is about 75 miles away from Pasni.

3. The magnitude and energy of the earthquake.—From the available seismograms, the Milne-Shaw north-south component seismograms of Bombay and New Delhi were useful.

The following method for calculating the magnitude of the earthquake was used for the data of each station.

A' (the maximum amplitude of the recorded trace in millimetres) and T (the corresponding period of the ground movement in seconds) were measured from the seismogram. a (the true ground displacement in microns corresponding to A') was computed (using the appropriate dynamic magnification factor). Then the values of a and T were substituted in the equation

$$A = \frac{V}{1000\,[(u^2-1)^2+4h^2u^2]^{\frac{1}{2}}}\,a\,,$$

where $V = 2800$, $u = \dfrac{T}{T_0}$, $T_0 = 0{\cdot}8$ secs., $h = 0{\cdot}8$.

A gives the amplitude (in millimetres) of the trace recorded at the station by a standard torsion seismometer (a seismometer having the constants prescribed above) corresponding to A'. M (the magnitude of the earthquake) was then calculated by means of the formula

$$M = \log A - \log A_0,$$

where $\log A_0$ depends only on $\triangle$ (the epicentral distance of the recording station). A comprehensive discussion of the question of the magnitude and energy of earthquakes is given in section V of B. Gutenberg and C. F. Richter's paper " On Seismic Waves (Third Paper)", Gerlands Beiträge zur Geophysik, vol. 47, pp. 73—131, 1936 ; and the value of $\log A_0$ corresponding to an assigned value of $\triangle$ can be read off from Fig. 6 on p. 120 of the paper.

After calculating M for both the stations and taking the average of the two values the energy of the earthquake was calculated by means of the formula

$$E = E_0 \, 10^{2M}$$

where the value of E_0 has been empirically taken to be 10^8 ergs by the above authors.

The results of the calculations are given in the following table :—

Station.	A'	T	a	A	log A	Δ°	log A_0	M
	mm.	sec.	μ	mm.				
Bombay	95	18	250	5·3	0·72	11·0	—5·9	6·6
New Delhi	100	28	2220	5·1	0·71	13·9	—6·0	6·7

Mean value of $M = 6{\cdot}65$

Hence

$$E = 10^8 \times 10^3 \times {}^{6.65} \text{ ergs}$$
$$= 10^8 \times 10^{13.3} \text{ ergs}$$
$$= 10^{21.3} \text{ ergs.}$$

Thus the estimate of the magnitude of the earthquake is about 6·7 and that for the energy of the order of 10^{21} ergs. From Gutenberg and Richter's tables giving their estimates of selected shocks, we find the following earthquakes whose magnitudes are approximately 6·7, *i.e.*, the magnitude of the Mekran earthquake.

Date	Epicentre in
1932 July 12	Gulf of California
1932 December 7	Mexico
1934 January 28	Mexico
1934 May 4	Alaska
1934 July 28	Alaska
1934 November 30	Mexico

For purposes of comparison of the earthquake under consideration with others as regards magnitude, the following list of a few selected earthquakes is given from the material provided by Gutenberg and Richter.

Date	Epicentre in	Magnitude
1905 April 4	Kangra, India	7¾
1912 May 23	Burma	8
1912 August 9	Turkey	8
1922 November 11	Chile	8·4
1923 September 1	Japan	8·1
1933 March 2	Japan	8·3
1934 January 15	Bihar	8·2
1935 May 30	Baluchistan (Quetta)	7·7

It is seen, therefore, that in comparison with prominen large earthquakes of the past, the Mekran earthquake was not particularly important so far as its magnitude is concerned. Its importance and interest are due to the seismic sea wave associated with it.

In contrast with the Quetta earthquake, which caused great destruction locally, this earthquake, by itself, did little damage ; the damage was due to the seismic sea wave.

4. The area affected by the earthquake.— The places in India most distant from the epicentre where the earthquake was experienced were Dera Ismail Khan and Montgomery. The distribution of the intensity of the ground motion due to the earthquake is shown in the accompanying map showing the isoseismal lines.

From the elliptical isoseismal lines, we can draw the following conclusions :—

(1) The intensity of the shock falls off much less rapidly along the major axis than along the minor axis.

(2) The main direction of the distribution of the shock is almost parallel to the north-east through the epicentre.

(3) The areas in square miles for the different intensities can be approximately indicated as follows* :—

Intensity (Rossi-Forel Scale)	Area (Thousand square miles)	
> 10	11·5	21·5
> 8	33	55
> 7	88	352
> 5	440	

(In making the above estimates of the areas the following assumption has been made: —

The portions of the isoseismal lines in the region under sea are such that the complete isoseismals are symmetrical about the north-west direction through the point 24·3°N., 63°E., which is approximately at the centre of the system of isoseismals.)

5. The sea wave associated with the earthquake.—Level changes of as much as 50 feet have been recorded in connection with fault movements causing earthquakes. Sea waves are produced whenever such changes, or extensive landslides, occur in the sea bed. Owing to their association, in most cases, with earthquakes, these waves are called seismic sea waves or " Tunamis " and, popularly though erroneously, Tidal Waves.

Not all land earthquakes are accompanied by surface fault movements. Similarly, not all submarine shocks are accompanied by changes in the level of the sea bed and the resulting seismic sea waves. Actually, it is found that the number of submarine earthquakes, which cause destructive sea waves is very small.

The earthquake in question was attended by a seismic sea wave which affected the whole of the Arabian sea-board. Karwar, about 1,000 miles away from the epicentre, was the most distant place at which the ' tidal ' wave was reported to have produced tangible effects. At Karwar, the wave flooded the creeks and inlets, and boats anchored in the harbour were cut off from their moorings, though no damage was done. The available information regarding the wave is summarised below.

Mekran Coast.—Pasni, an important trading centre along the Mekran Coast and distant about 75 miles from the epicentre, was overwhelmed by the wave, there being serious loss of life and property. At about 4 A.M. a wave was noticed but it did not come inland. At about 7-15 A.M. another wave swept over the town and caused widespread havoc. The height of this wave has been estimated variously from 40 ft. to 50 ft. Serious loss of life and property was also caused at Ormara (about 130 miles away from the epicentre) and in several coastal villages. Large quantities of fish were washed inland on the coast.

Karachi.—Karachi, which is at a distance of about 275 miles from the epicentre, experienced waves affecting the harbour at 5-30 A.M., 7 A.M., 7-50 A.M. and 8-15 A.M. The last one was the largest and its height was estimated to be 4½ ft. above normal. Fortunately, the times at which the waves occurred were different from the times of high tide at Karachi on that day, namely, 06h. 37m. and 19h. 45m. I.S.T. The last wave, which was the largest, is reported to have produced a strong ebbing current of between 4 and 5 knots, apparently during its recession. The wave caused damage in the Karachi harbour and loss of life and property along the Karachi coast.

*The figures in the last column give the areas (in thousand square miles) of the portions between the successive isoseismals.

Bombay.—Bombay, 750 miles away from the epicentre, experienced a wave at 8-15 A.M., its height being 6½ ft. There was some loss of life. Fortunately, however, the times of high tide for the day were 06h. 58m. and 20h. 12m. I.S.T.

6. Additional information regarding the earthquake.—It has been reported in the Press that two rocky oval islets were thrown up by the earthquake about 180 miles west-south-west of Karachi. The islets are about 3 miles apart, one rising about 30 feet above the water and the other about 100 feet ; the former is about one and a half square miles and the latter about a square mile. When the officer commanding the Indian naval ship *Hindustan* first saw the new islets, he examined his charts and then sent out the following signal : " Two uncharted islets have appeared in the approximate position of 25 degrees and 7 minutes north, and 64 degrees and 15 minutes east ". A correspondent of the Associated Press of India who was on the ship has reported that, according to the information gathered from the villagers, immediately after the earthquake a loud rumbling noise was heard and was followed by a huge sheet of flame and columns of smoke and that these were followed by the seismic sea wave.

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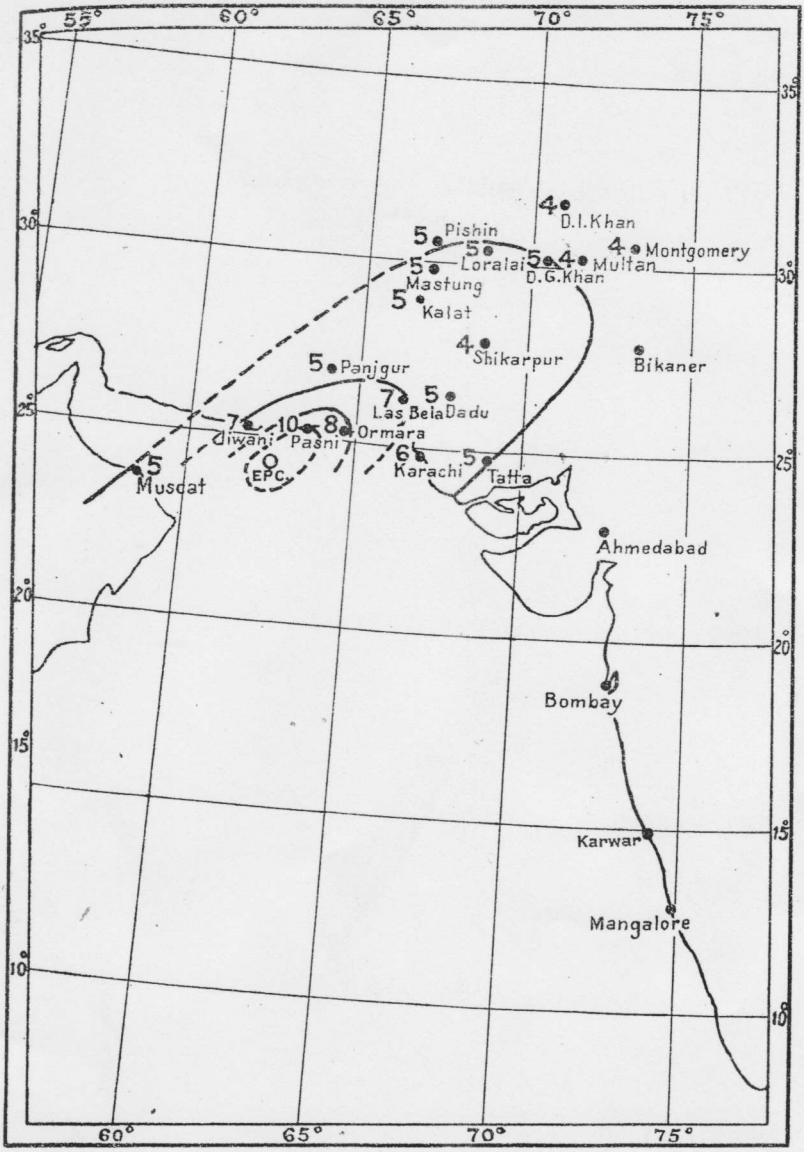

Isoseismals of the earthquake –
of 1945 Nov. 27 d. 21 h. 57 m. (approx.) G.M.T.

G. P. Z. P. POONA, 1947.