STUDY OF EARTHQUAKE SEQUENCES IN ASSAM AND NEIGHBOURHOOD FOR THE PERIOD 1918–62.

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SYNOPSIS

Frequency distribution of earthquakes in Assam region has been studied for the period 1918—1962. Earthquake sequence in general, and after shock sequences of major shocks in particular, indicate the influence of regional structural features on the nature of release of earthquake strain energy.

INTRODUCTION

Placing of Assam region in one of the known seismic belts of the world presents difficulties. That Assam Himalaya is a part of tran-Asiatic Alpide belt of tectonic feature is evident enough. The seismicity of Assam, however, is so closely linked with Burma that it is difficult to view these two features separately. It was mainly to avoid this difficulty that Gutenberg (1954), overriding seismic and structural data to the contrary, considered the Himalayan and Burmese areas as coming under the Himalayan system. The author (1964) in his examination of seismic regionalisation of Assam pointed out the basic differences in the two arcuate activities of the region. It was also pointed out that these two arcuate features are separated by a 'block' tectonic environment running along the length of Assam in a general north-easterly direction. This view, based mainly on seismic data, is supported by the frontal pattern of mountain arcs of the region. Alpide belts in Asia (of which Himalayas form a part) all show convexity towards south while the Burmese arcs, in close resemblence to the Sunda arc continuation, show west-ward convexity. Gutenberg (1954) has however, pointed out that seismic evidences are insufficient to establish a direct connection between the activities of Burmese and Sunda arc sectors. From all these indications, it appears that the Burmese activity should be considered as a feature different from that of Himalayan activity.

The regional complexity of Assam thus arises out of the positioning of the fold resistant Archean wedge sandwiched between two compressive stress fields. The process results in the development of complex force field within and around the basically 'stable'

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platform. The four zones of tectonic activities of this region, earlier discussed by the author (1964), are based upon both structural complexities and stress field distribution of this area.

In the present study, an analysis of the frequency distribution of significant tectonic movements of the region has been made and the influence of the environment of such frequency distribution examined.

DATA AND METHOD OF ANALYSIS

The period covered in the present study is from 1918–1962 (45 years). All significant tectonic disturbances with lower magnitude limit 4 on the Gutenberg-Richter scale of seismic magnitude were used for the present study. Scarcity of reliable instrumental data however severly restricted the scope of the study. Epicentres of earthquakes used in the study were all checked afresh on the basis of available data. Travel time values used for all determinations were those given in "Seismological tables by Jeffreys and Bullen" (1948). The table at the end gives year and region wise distribution of earthquake epicentres in and around Assam. Figures 2 through 5 present graphically the frequency distribution of earthquakes of the four zones separately while figure 1 gives the frequency distribution of earthquakes of the region as a whole. Though all available data were freely used, yet following sources were found outstandingly valuable :

1. International Seismological Summary.
2. Bulletin of the Bureau Central International de Seismologie.
3. Seismological bulletins of India Meteorological Department.
4. Bulletins and other publication of the United States coast and Goedetic Surveys.
5. Unpublished records and data of India Meteorological Department.

Prior to 1951 no seismological station was operating within the region and the efficiency of the recording seismographs, both within and outside India, was rather low. With the commissioning of a powerful seismograph station at Shillong and a subsidiary station at Tocklai (Jorhat) from 1951, considerable improvement in the recording efficiency of the earthquakes of the region was noticed. Data used in the table for the period 1952 onwards are quite complete for the purpose of present study, but for earlier periods such high order of completeness cannot be claimed.

FREQUENCY DISTRIBUTION OF EARTHQUAKES

For the purpose of present study, annual occurances of major shocks and the total number of shocks of all categories, for all four regions, have been treated separately. Shocks of magnitude =7 and above have been treated as major shocks. This criterion has been used mainly for the understanding of the frequency of occurance of earthqnakes which are capable of causing damages to engineering structures over wide areas. Major shocks have been

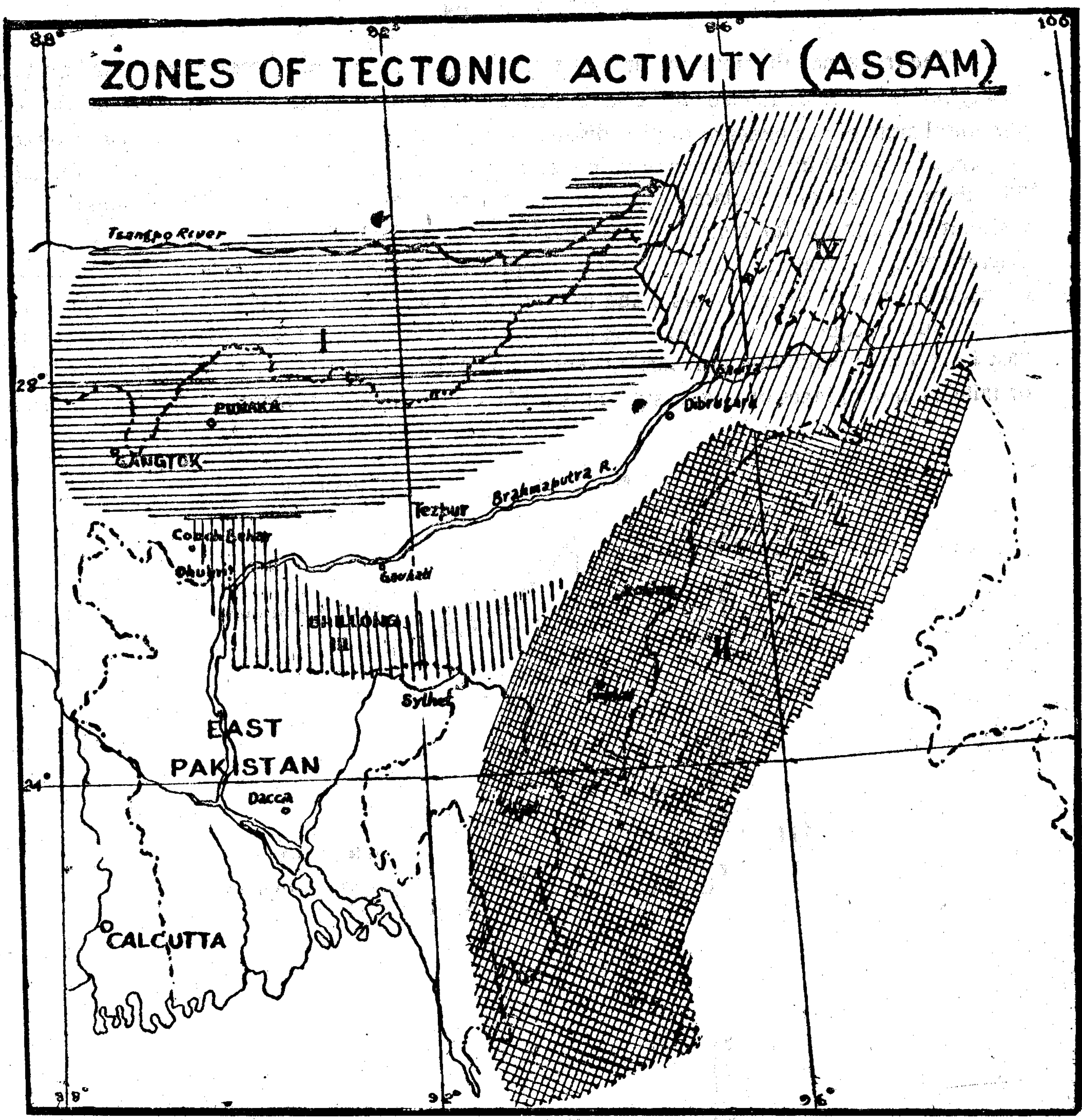

Figure 6

represented in Figs. 1 through 5, by vertical columns with lengths proportional to the number of such shocks. The continuous curves in all figures give the frequency distributions of total number of earthquake shocks. Total number of earthquakes used for the present study is 473. Fig. 6 indicates the four zones of seismic activity of the region as discussed earlier by the author (1964).

DISCUSSION

The frequency distribution curve of a zone indicates the general sequence of earthquake energy release and are related to the stress field responsible for the process as well as the structural state of the material of the disturbed region. The author (1964) earlier showed that the stress field in Assam region is fundamentally compressive and uniformly distributed. The shear type stress in isolated areas originate only out of local reaction of stable and resistant strata to the fundamental stress field. Mogi (1963) studied the nature of brittle fracture of model materials under uniform compressive stress and pointed out an intimate connection between structural state and nature of fracture. The interpretation of the nature of earthquake sequences of different areas on the basis of Mogi's experimental results are based upon the assumption that earthquckes are caused by brittle or semi-plastic fractures or failures along planes of weaknesses in earth's crust or upper mantle. Recently Evison

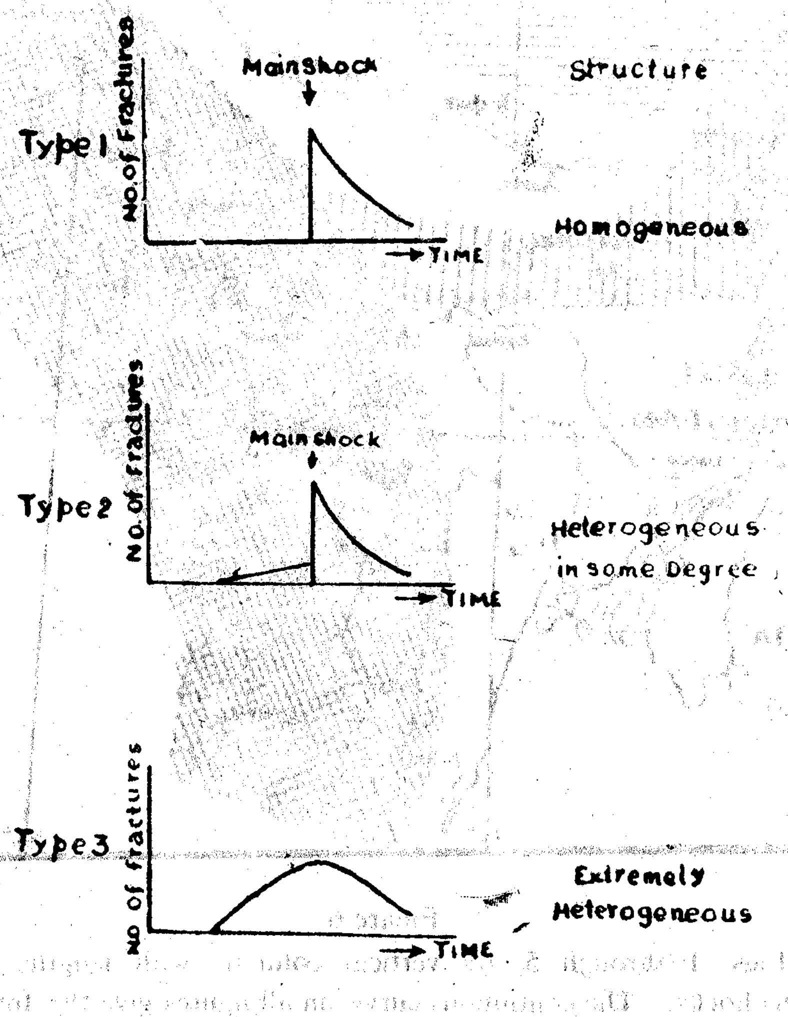

Fig. 7 Schematic Representation of Frequency Curves of Brittle Fracture in Different Model Materials under Compressive Stress (based on Mogi's experimental data)

(1963) reviewed the weakness of such assumption but nevertheless observations of both earthquake mechanism at source and surface effect near epicentral regions of major earthquakes still seem to overwhelmingly support this view. Mogi's experimental data can thus be used for examining the effects of structural inhomogenity upon the earthquake sequence of zones of tectonic activities in Assam. Fig. 7 above schematically presents the frequency distribution curves of elastic shocks, under compressive stress (based on Mogi's experiments).

Frequency distribution of earthquake of different regions of earth shows striking resemblance to the above schematic presentation of brittle fractures. As the stress field in Assam region is basically compressive in nature, the frequency distribution curves of this region may be examined for an indication of the structural state of the different zones of the region. But because of inherent incompleteness of the basic data, it is possible to examine this aspect of seismicity on general terms only. If the earthquake sequences of the four zones of Assam region are examined in the above light, then it is observed that sequences of both zones I and II resemble the fracture pattern of type II while sequences of zone III and IV resemble that of type I in Fig. 7 above. However for this purpose it is necessary to treat the upheaval of 1950 on a different footing. The instability that resulted in the earthquake sequences of 1950 effected the neighbouring areas also through elastic rebound and analysis of aftershock sequences of the main shock of 15th August 1950 (Epc–28·7N 96·6E, origin time–14h 09m 30s GMT Magnitude–8·6) show that the main shock originating from Zone IV had in its sequence of aftershocks a series of shock (some of them major) originating from bordering areas of zone I and II.

From Figs. 2 and 3 it will also be seen that generally major shocks of zones I and II are preceeded by a slight increase in the normal seismic activity of the region and that after shock sequences for major shocks are either absent or fall off rather rapidly. Again from Figs. 4 & 5 it will be observed that major shocks of zones III and IV are generally preceeded by a period of quiescence during which the seismic activity is lower than the normal level. However all major shocks from zones III and IV are followed by large trains of after shocks which die off slowly. In some cases energy levels of a few aftershocks are quite high and the sequence of aftershock is complicated by the presence of such secondary sequences.

Both Dhubri earthquake of 1930 and Assam earthquake of 1950 (originating from Zone III and IV respectively) exhibited such complicated phenomena. Thus in both zones III and IV the mechanism of elastic strain release is in the form of intense energy bursts followed by periods of quiescence, while in zones I and II though the normal level of activity, in terms of frequency of disturbances, is relatively high yet the burst of high energy releases are not as high as in other two zones and viewed on frequency distribution curves the energetic bursts are very much less conspicious for Zones I and II as compared to Zones III and IV.

The nature of earthquake sequences of different zones of Assam, viewed in the light of Mogi's (1963) observation of fracture pattern of model materials, indicate a comparatively homogenous structure for zones III and IV as compared to zones I and II. It seems that the seismicity of both zones I and II are connected to the development of folded mountains of the arcúate Himalayan and Indo-Burmese system, through comparison of Geosynclines while activities of zones III and IV are caused by the block tectonic degeneration of the ancient platform represented by the Assam plateau. The nature of activity of the platform seems to be a similar to that of Central Asian platform as observed by Gorshkov (1959).

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YEAR WISE AND REGION WISE DISTRIBUTION EARTHQUAKE EPICENTRES IN AND AROUND ASSAM (1918—1962)

Year	No. of shocks originating from Region					Major shocks Magnitude =7 & above	Remarks
	I	II	III	IV	Total		
1918	—	—	1	—	1	1	Major shock originated from Zone III
1919	—	—	—	—	—	—	—
1920	—	1	—	—	1	—	—
1921	—	1	—	—	1	1	Major shock originated from Zone II
1922	—	—	—	—	—	—	—
1923	—	1	1	—	2	1	Major shock originated from III
1924	1	3	1	—	—	5	—
1925	—	—	—	—	—	—	—
1926	—	4	1	1	6	—	—
1927	—	2	1	1	4	1	Major shock originated from II
1928	1	1	1	2	5	—	—
1929	1	8	—	1	10	—	—

(Continued)

Year	No. of shocks originating from Region I	II	III	IV	Total	Major shock Magnitude =7 & above	Remarks
1930	—	16	9	—	25	1	Major shock originated from III
1931	—	9	1	4	14	1	Major shock originated from II
1932	1	5	4	—	10	1	Major shock originated from II
1933	—	7	1	2	10	—	—
1934	—	3	—	—	3	—	—
1935	1	3	1	—	5	—	—
1936	1	3	2	—	6	—	—
1937	2	4	—	—	6	1	Major shock originated from II
1938	2	3	1	1	7	2	Both major shocks originated from II
1939	—	2	—	—	2	1	Major shock originated from II
1940	2	1	—	—	3	1	Major shock originated from I
1941	6	4	1	1	12	3	One major shock originated from I and two from II
1942	1	—	1	—	2	—	—
1943	1	—	—	—	2	1	The major shock originating from near Jorhat and outside the marked region.
1944	1	1	1	—	3	—	—
1945	—	—	1	—	1	—	—
1946	1	8	—	1	11	2	Both the major shocks originated from II, one shock originated from near Nowgong and outside the marked region.
1947	2	6	—	—	8	1	Major shock originated from I
1948	1	2	2	—	7	—	Two shocks originated from near Jorhat and outside the marked region.
1949	—	4	1	1	6	1	Major shock originated from III
1950	33	11	2	42	88	13	Major shocks :- 4 from I, 2 from II and 7 from IV
1951	9	5	2	9	25	2	Major shock :- 1 from I and 1 from III
1952	3	6	—	2	11	—	—
1953	—	1	1	2	4	—	—

(Continued)

Year	No. of shocks originating from Region					Major shock Magnitude =7 & above	Remarks
	I	II	III	IV	Total		
1954	1	1	—	2	4	1	The major shock originated from II
1955	2	7	3	1	13	—	—
1956	2	12	3	3	20	1	The major shock originated from II
1957	—	10	1	2	13	1	The major shock originated from II
1958	5	10	1	—	16	—	—
1959	9	12	1	9	31	—	—
1960	4	11	3	4	22	—	—
1961	9	14	2	3	28	—	—
1962	2	10	3	5	20	—	—
45 Years	104	212	54	99	473	38	Four shocks with origin outside marked region.

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ANNUAL DISTRIBUTION OF EARTHQUAKES ORIGINATING FROM ASSAM & NEIGHBOURHOOD
(1918-1962)

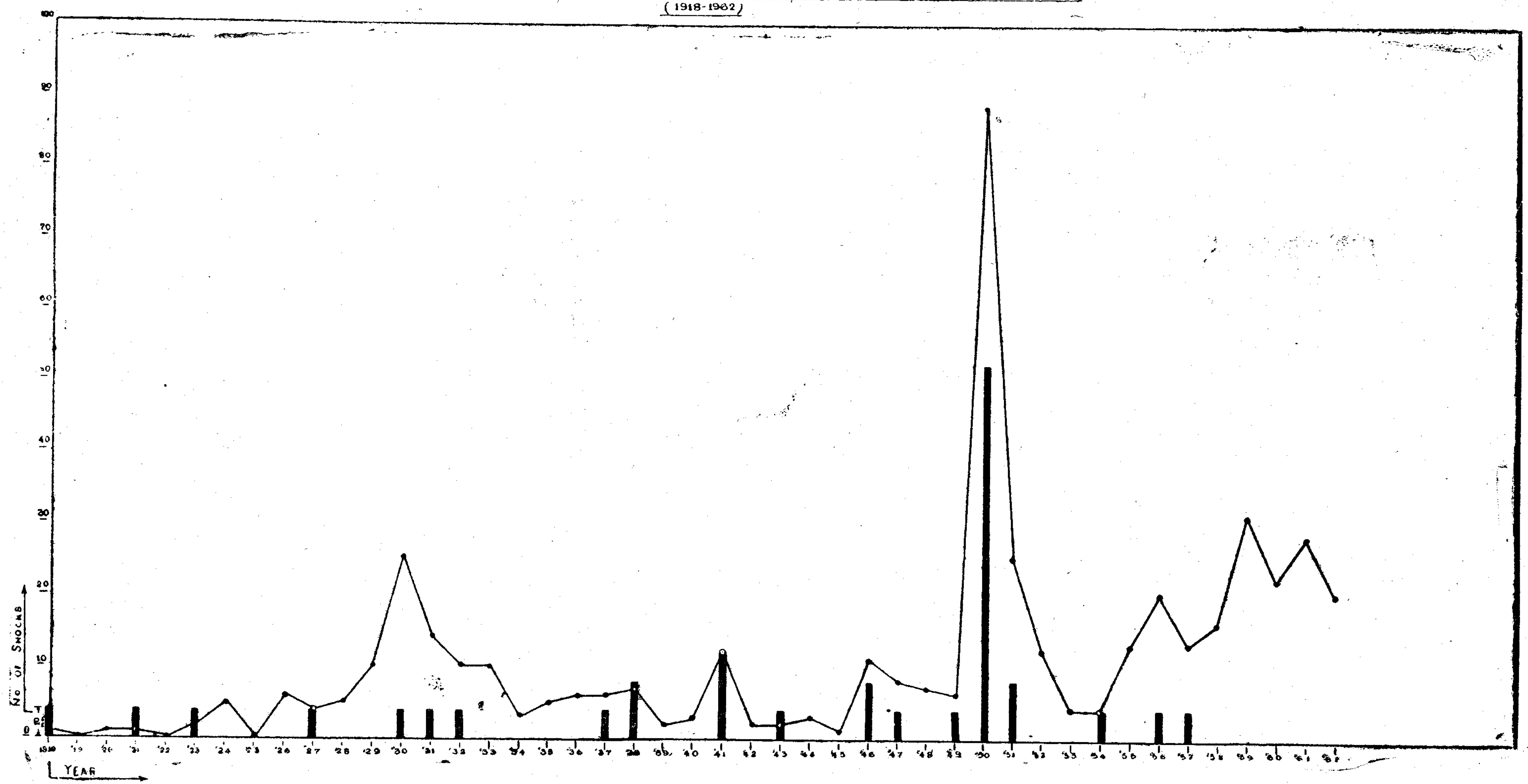
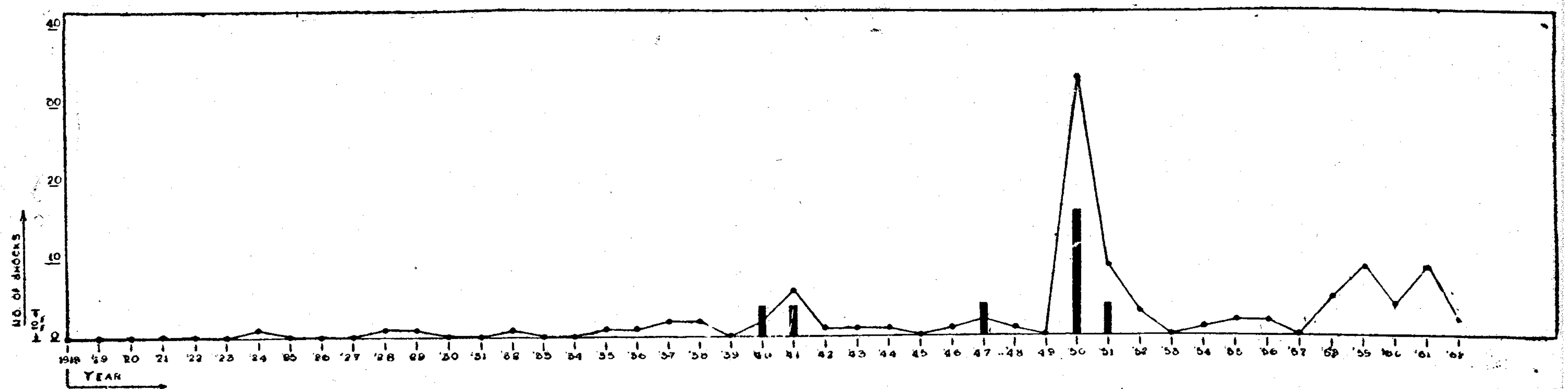
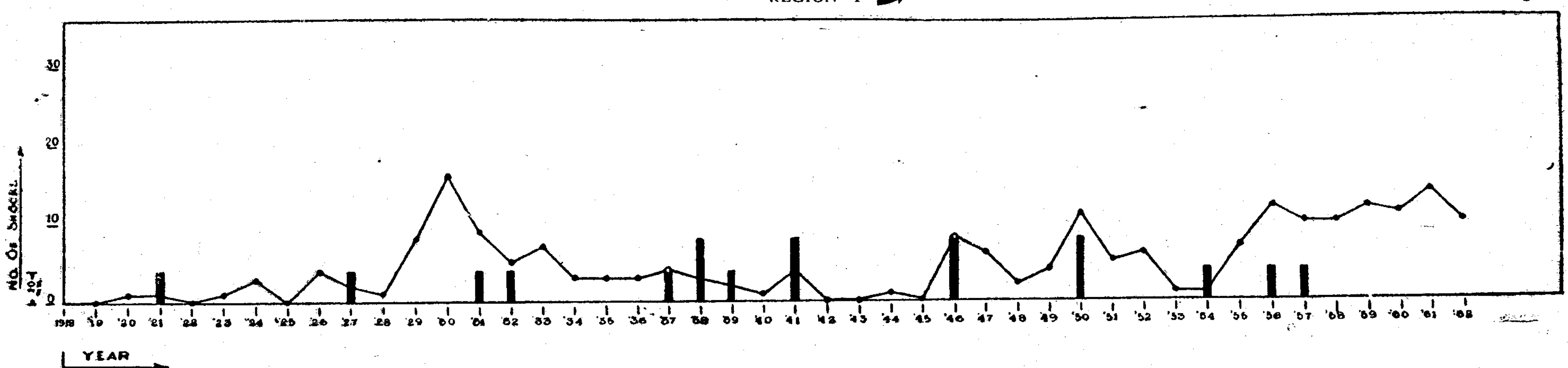


Figure 1



REGION I

Figure 2



REGION II

Figure 3

ANNUAL DISTRIBUTION OF EARTHQUAKES ORIGINATING FROM REGION - III (1918-1962)

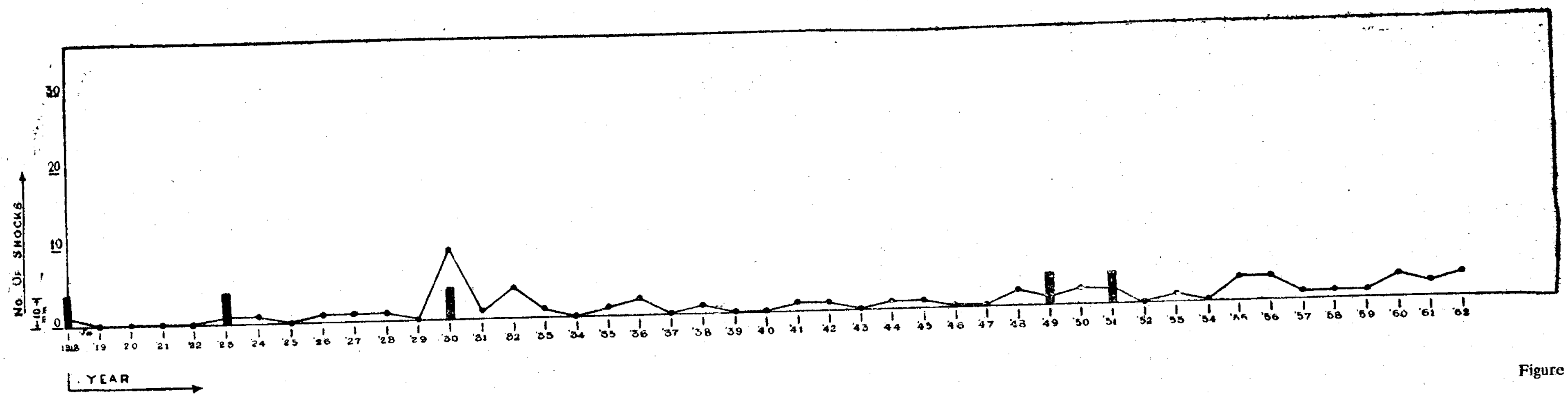


Figure 4

ANNUAL DISTRIBUTION OF EARTHQUAKES ORIGINATING FROM REGION-IV (1918 - 1962)

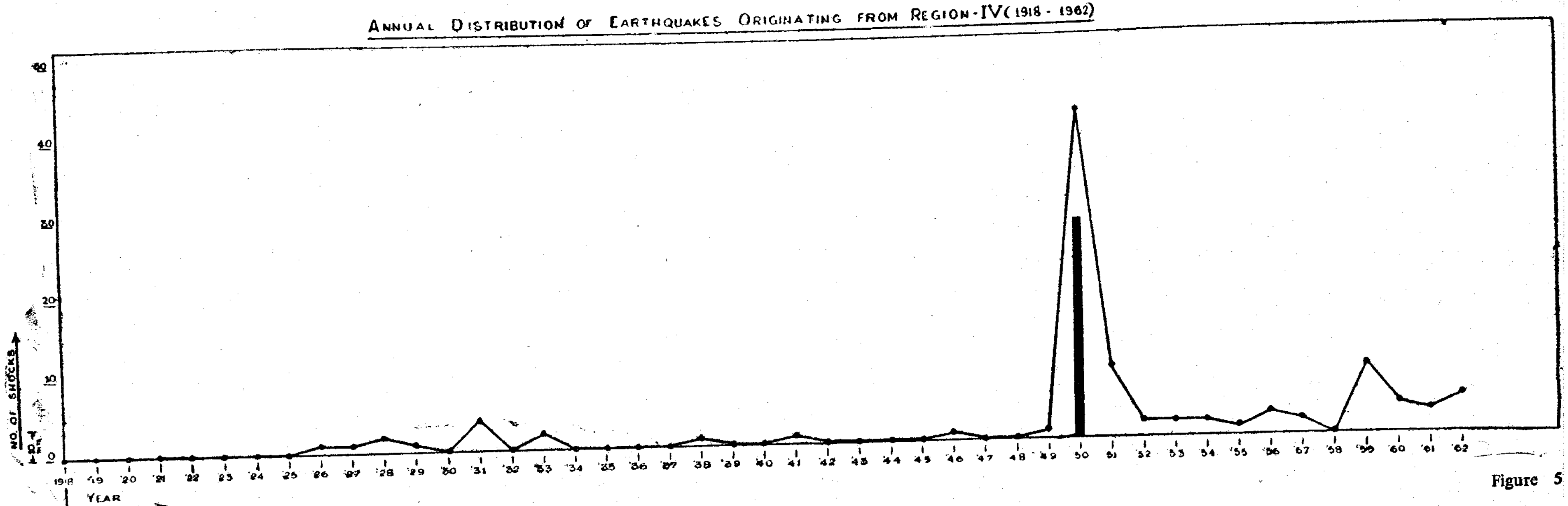


Figure 5