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A SHORT NOTE ON THE NAGALAND EARTHQUAKE OF JULY 29, 1970

S.K. GUHA* AND P.D. GOSAVI*

INTRODUCTION

At 1016 hrs G.M.T. on July 29, 1970, North Eastern part of India covering an area of about 2,80,000 sq.km. in Assam, Meghalaya, Mizoram, Arunachal, Tripura, Manipur, Nagaland, parts of West Bengal and Bangladesh was rocked by an earthquake of Richter Magnitude 6.4. A questionnaire programme was undertaken immediately after the earthquake for assessing seismic intensities in MM (1931) scale in areas affected by the quake for the purposes of preparing isoseismal map. A macroseismic survey in the epicentral region was undertaken by Geological Survey of India (1970). Maximum intensity approaching VII was assigned to area around Margherita and Digboi where some damage to housing property occurred. No damage to roads, bridges and railway track was reported. Distributions of earthquake intensities clearly show the influence of regional geology and local foundation conditions. Epicentral tract runs NE–SW and indicates possible tectonic adjustments along Haflong-Dissang Thrust fault.

Cretaceous and Lower Tertiary rocks are found over a large part of Shillong plateau together with Mikir Hills on its east. Shillong plateau together with Mikir Hills is a horst which has been uplifted during the Tertiary period. Northern side of this plateau facing the Brahmaputra Valley is marked by a steep fault. Its southern side is also faulted and a dextral transcurrent fault known as Dauki fault runs over a distance of 250 km along which Assam plateau has moved eastwards with respect to Bangladesh plains. Throw of this fault diminishes eastwards and its character and direction changes near Haflong from where it runs in North-Easterly direction for nearly 400 km into upper Assam and is a prominent thrust directed towards the Brahmaputra Valley. Between it and the Naga thrust is a zone of several intricate thrust faults all directed to the North-west. Naga thrust is complex in nature and consists of at least four thrust faults (Krishnan 1966).

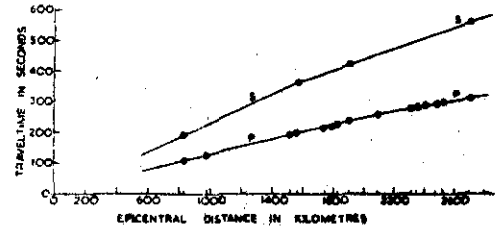

Fig. 1. Travel Time curves of P and S phases recorded in the Indian Stations (Nagaland Earthquake of July 29, 1970).

Aeromagnetic surveys carried out for petroleum prospecting indicate that Basement rocks in the Brahmaputra valley in Assam could be at depths of about 7500 metres. Bore holes have penetrated only to a depth of 3500 to 4000 metres upto formations belonging to Oligocene and Eocene period. Mesozoic rocks are likely to underlie these formations. The sharp bend in the formation beyond the North-eastern corner of Assam can be attributed to a wedge of resistive precambrian block which extends from the Mikir Hills towards upper Assam.

* Central Water and Power Research Station—Poona-24.

North-Eastern part of Indian subcontinent has been rocked by devastating earthquakes from time to time in the past. However, systematic account of big earthquakes in Assam is available from the middle of the 19th century. Appendix-I presents a list of as many as 18 earthquakes of Richter Magnitude 6.5 and above which occurred in Assam and surrounding areas during last one hundred years. Epicentres bearing serial numbers as in Appendix-I have been plotted in Fig. 2.

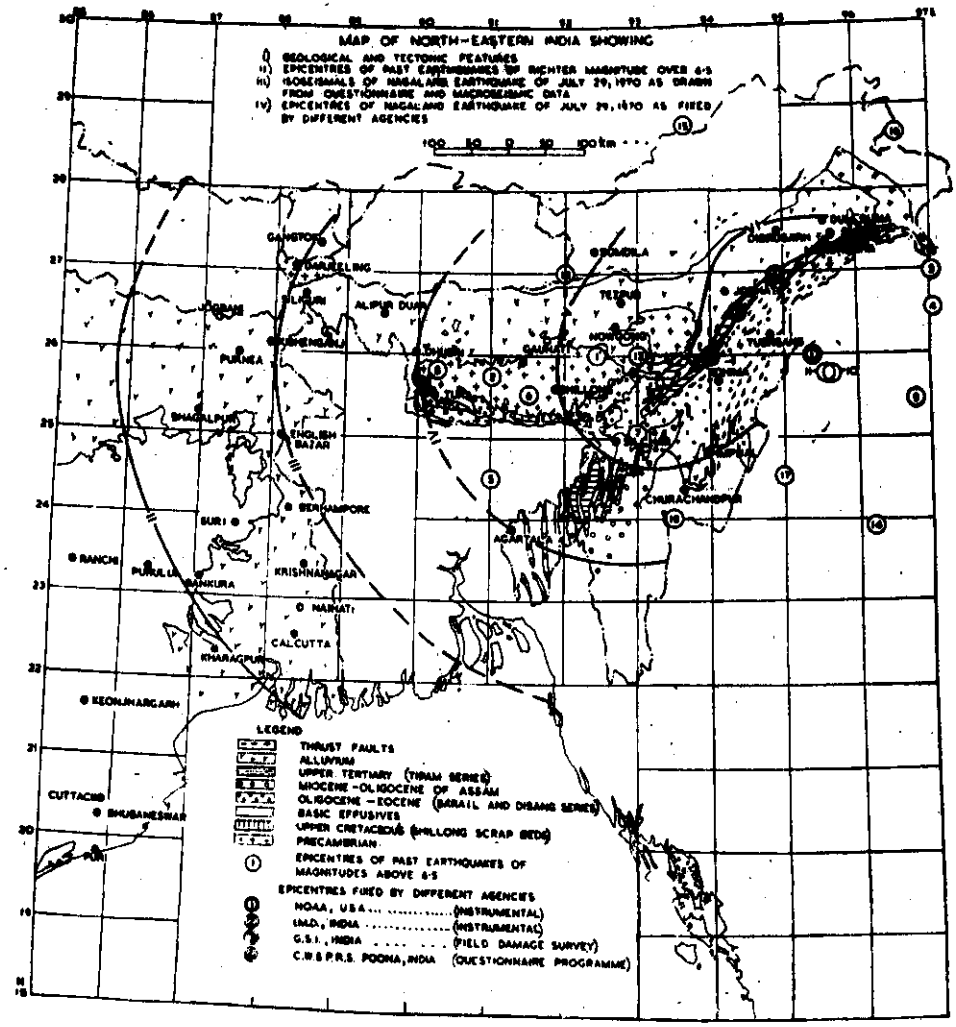

Fig. 2. Isoseismal map of Nagaland Earthquake of July 29, 1970.

FIELD SEISMOLOGICAL STUDIES

Nagaland earthquake of July 29, 1970 was extensively recorded by seismograph stations spread all over the world. In India it has been recorded by the seismographs working in different parts of the country. Seismological parameters of this earthquake as reported by the National Oceanic and Atmospheric Administration (NOAA) U.S.A. are as follows :

Epicentre	:	Lat. 26° N; Long. 95.4° E near India Burma border
Origin Time	:	10 h 16 m 19.3 s G.M.T.
Depth of Focus	:	59 km
Magnitude M	;	6.4

Fig. 1 shows the travel time curves of the earthquake phases P and S from the Indian Stations.

Immediately after the occurrence of the earthquake a questionnaire programme was undertaken for assessing seismic intensities in MM (1931) scale in areas affected by the quake for the purposes of preparing an isoseismal map. These studies were supplemented by macroseismic studies carried out by other agencies such as Geological Survey of India (1970) etc. Fig. 2 shows the isoseismal map obtained from the data. Appendix II gives the list of places where the MM intensities were assigned from field survey.

DISCUSSIONS AND CONCLUSIONS

Epicentre of the earthquake from questionnaire and macroseismic data has been placed at Lat. 26°.9 N; Long. 94°.9 E in the vicinity of the towns of Margherita and Digboi from where the maximum damage to surface property was reported. It is observed from the isoseismal map that maximum intensity tract runs NE–SW along Haflong-Dissang Thrust fault. Distribution of earthquake intensities shows the influences of regional geology and local foundation conditions such as at Imphal where local accentuation in ground vibrations could be attributed to thick sedimentary cover. Structural response recorder studies made by Agrawal (1972) corroborate these observations.

Accepting instrumentally assessed magnitude M (=6.4) and observed maximum intensity I_0 (> VI (MM)), other parameters can be computed from the relations given by Medvedev (1962), Shebalin (1957) and Gutenberg and Richter (1942). The following equation due to Medvedev gives depth of focus (h)=59 km

$$I_0 = 1.5\,M - 3.5 \log h + 3$$

Similarly, depth (h) as calculated from Shebalin's following equation :

$$M = 0.7\,I_0 + 2.3 \log h = 2.0$$

works out to be 51 km.

From seismograms recorded in the Koyna seismograph net and at Poona it is possible to identify arrival of p^P phase about 9 seconds after the arrival of P phase indicating that the depth of focus is about 60 km, Jeffreys and Simshoni (1964).

Radius of felt area (r) as given by Gutenberg-Richter relation :

$$\frac{p}{h} = \left[10^{(I_0/2-1)} - 1\right]^{\frac{1}{2}}$$

for h=59 km—is 384 km.

Depth of focus as calculated from the instrumentally assessed magnitude and the maximum intensity as assigned from the surface damages reported agrees very well with the instrumentally computed results. Radius of felt area given by the Gutenberg-Richter relation also gives very reasonable value of 384 km and the same tallies well with the area enclosed within isoseismal II. Elongation of isoseismals in NE-SW direction and disposi-

tion of maximum intensity tract parallel to Haflong-Dissang thrust fault indicates possible tectonic adjustments along this fault.

ACKNOWLEDGEMENT

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APPENDIX I

List of earthquakes of magnitude greater than 6.5 with their epicentres located in Assam and surrounding areas

Sr. No.	Date of occurrence	Epicentre Lat.	Epicentre Long.	Maximum Intensity I_0 MM Scale	Magnitude Richter Scale	Source of Information	Brief Description and Remarks
1	2	3		4	5	6	7
1.	10.1.1869	Cachar, Assam (NE of Shillong Plateau)		—	—	Oldham	The shock was felt over an area of 250,000 sq. miles. Earth fissures and sand craters were abundant.
2.	12.6.1897	Shillong Plateau		—	—	Oldham	R.D. Oldham has described this earthquake as "an earthquake which has not been surpassed by any other earthquake in the historical record in its violence and extent." This was felt over an area of 1,750,000 sq. miles. Wide spread damages to roads, building, railway tracks, and bridges occurred in different parts of Assam. About 1600 livers were lost. The shock was severely felt as far away as Calcutta. After shocks continued for 10 years.
3.	31.8.1906	27° N; 97°E		IX	7.0	I.S.S.	Depth of focus about 100 km.
4.	12.12.1908	26° .5N; 97°E		X	7.5	I.S.S.	Shallow focus.
5.	8.7.1918	24° .5N; 91°E 3½ miles south of Shrimangal		X	7.6	I.S.S.	Extensive destruction in tea estates felt over an area of 89,000 sq. miles in Assam.

Sr. No.	Date of occurrence	Epicentre Lat.	Epicentre Long.	Maximum Intensity I_0 MM Scale	Magnitude Richter Scale	Source of Information	Brief Description and Remarks
1	2	3		4	5	6	7
6.	10.9.1923	25°.5 N;	91°.5	IX	7.1	I.S.S.	Felt over large areas in Assam, Bengal, Bihar and Chota Nagpur. Damages caused to buildings in the epicentral region.
7.	30.1.1924	25° N;	93°E	IX	7.0	I.S.S.	
8.	3.7.1930	25°.8 N;	90°.2E near Dhubri	IX	7.1	I.S.S.	Severe. Felt over an area of 350,000 sq. miles. Followed by large number of aftershocks.
9.	27.1.1931	25°.4 N;	96°.8E	X	7.6	I.S.S.	
10.	14.8.1932	25°.8 N;	95°.7E (NW Burma)	IX	7.0	I.S.S.	Semi destructive in the epicentral tract and eastern part of NE Assam. Felt over extensive area in Burma, Assam and Bengal.
11.	4.12.1933	25°.8 N;	95.6E	IX	7.0	I.S.S.	
12.	21.1.1941	27° N;	92°E	IX	6.75	I.S.S.	Damages reported from epicentral region. Felt in Assam and North and East Bengal.
13.	23.10.1943	26° N;	93°E	IX	7.2	I.S.S.	Shallow focus. Destructive in NE Assam. Minor damages in North Assam. Felt over Assam, Bengal, Eastern parts of Bihar and NE parts of Orissa.
14.	12.9.1946	23°.9 N;	96°.2E	X	7.5	I.S.S.	Felt in Narayanganj, Noakhali, Silchar and lakes and reservoirs in Noakhali were disturbed due to large wave.

Sr. No.	Date of occurrence	Epicentre Lat.	Epicentre Long.	Maximum Intensity I_0 MM Scale	Magnitude Richter Scale	Source of Information	Brief Description and Remarks
1	2	3		4	5	6	7
15.	29.7.1947	28°.8 N	93°.7E	X	7.75	I.S.S.	Wide spread damage in Dibrugarh, Jorhat, Tezpur. Shock was extensively felt in Assam, Bengal as far as Calcutta and in the town of Purnea in Bihar.
16.	15.8.1950	28°.7 N	96°.6E	IX	8.6	I.S.S.	Caused wide spread damage throughout upper Assam particularly in frontier tribal districts of Mishmi, Abhor hills and parts of Jorhat and Lakhimpur district. Extensive damage was caused to roads, buildings, bridges, railway tracks and tea estates in Upper Assam. Gapping fissures and subsidences in ground was a common feature in Central Brahmaputra Valley. The main shock was followed by a train of aftershocks some of which reached destructive magnitudes in the epicentral tracts. At least two of the after shocks had a magnitude of 7.0.
17.	22.3.1954	24°.5 N	95°E	IX	7.25	I.S.S.	Depth of focus about 150 km. Felt locally over wide areas in Assam, Bengal, Bihar and Orissa.
18.	2.7.1957	24° N	93°.5E	VIII	6.8	I.S.S.	Felt widely in Assam, Manipur, Tripura and Bangla Desh. Minor property damage reported from Silchar, Gauhati, Golaghat and Karimganj in Assam.

APPENDIX II

List of locations where the Nagaland Earthquake of July 29, 1970 was felt and intensities assigned as per Modified Mercalli Scale (1931)

Sr. No.	Name of Locality	State	Latitude N	Longitude E
Intensity between VII and VI				
1.	Margherita	Assam	27°17′	95°40′
2.	Digboi	,,	27°33′	95°40′
Intensity VI				
3.	Amguri	Assam	26°47′	94°32′
4.	Jorhat Town	,,	26°46′	94°13′
5.	Lohitpur	Nefa	28°04′	96°34′
6.	Makum Jn	Assam	27°30′	95°28′
7.	Mariani	,,	26°38′	94°20′
8.	Nazira	,,	26°55′	94°44′
9.	North Lakhimpur	,,	27°20′	94°07′
10.	Panitola	,,	27°28′	95°20′
11.	Tinsukhia	,,	27°30′	95°22′
12.	Dimapur	Nagaland	25°54′	93°44′
13.	Dibrugarh	Assam	27°29′	94°54′
14.	Sibsagar	,,	26°59′	94°41′
15.	Dum Duma	,,	27°34′	95°33′
Intensity V				
16.	Baihata	Assam	26°21′	91°41
17.	Chapakowa	,,	27°57′	95°41′
18.	Dekiajuli	,,	26°42′	92°20′
19.	Dergaon	,,	26°42′	93°59′
20.	Haflong	Manipur	25°10′	93°02′
21.	Diphu	Assam	25°52′	93°27′
22.	Manipur	Manipur	24°44′	93°58′
23.	Nowgong	Assam	26°21′	92°45′
24.	Silghat	Assam	26°37′	92°56′
25.	Tezpur	,,	26°37′	92°50′
26.	Rangpara	,,	26°49′	92°39′
27.	Silchar	,,	24°50′	92°51′

Sr. No.	Name of Locality	State	Latitude N	Longitude E
28.	Jowai	Assam	25°27′	92°12′
29.	Imphal	Manipur	24°47′	93°58′
30.	Kampur	Assam	26°09′	92°39′
31.	Karimganj	,,	24°40′	92°30′
32.	Kohima	Nagaland	25°40′	94°12′
33.	Mokokchung	,,	26°20′	94°32′
34.	Shillong	Assam	25°33′	91°53′
35.	Tezu	Nefa	27°57′	96°16′
36.	Tuensang	Nagaland	26°16′	94°48′
37.	Ukhrul	Manipur	25°06′	94°22′
38.	Kharpatia Ghat	Assam	26°30′	92°09′
39.	Titabar	,,	26°36′	94°13′