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ISOSEISMALS OF BURMA-INDIA BORDER REGION EARTHQUAKE OF AUGUST 6, 1988

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ABSTRACT

A strong earthquake rocked the north-eastern states at 6:06 A.M. on August 6, 1988. In northeast India it was felt strongly and some damages were reported. An isoseismal map has been prepared on the basis of the information obtained from the residents of the affected area through a questionnaire, damage survey and using peak ground accelerations at various sites. Maximum intensity VII was observed at Diphu, Lumding, Tejpur, Jamuguri, Raha and Kamargaon (Assam) etc. The station Berlongfer and Diphu had a highest and second highest acceleration (0.337g and 0.331g respectively). The traditional and old construction without any earthquake resistance measures suffered maximum damage. The maximum peak ground accelerations were recorded around Diphu. Damage survey also indicated maximum intensity in this area.

INTRODUCTION

Various portions of the Himalaya have ruptured in the past, generating medium, large and even great earthquakes (Fig. 1). Loss of several thousand human lives and damage due to earthquakes keeps reminding us of the potential for great earthquakes in the shadow of the Himalaya.

A moderate earthquake of magnitude 6.8 occurred on August 6, 1988 in northeast India and Burma border region, that rocked vast area of northeast and eastern part of India. It was reported that the earthquake was also felt at distant places like parts of west Bengal, and Bihar etc. The earthquake was felt strongly in northeast India and some damage was also reported. A paper mill situated in the state of Nagaland, National Highway 37 near Raha (between Guwahati and Jagiroad) was damaged. The buildings in Guwahati, Jorhat, Sibsagar, Diphu, Silchar in Assam and in other parts of northeastern states also suffered damage. The earthquake caused land slides at several places including National highway 37 and Lumding - Diphu section of meter gauge railway line in Assam.

Macroseismic studies were undertaken to prepare the isoseismal map of the earthquake. The data on effects of earthquake were collected through a questionnaire. Instrumental data i.e., the data of strong motion array collected by a team of scientists of Earthquake Enginering Deptt. from various sites in the affected area [4,18,19]. About one thousand questionnaires were dispatehed/distributed to all the post offices, station masters and various organisations and, a response from about 25%, was received. On the Basis of these responses, isoseismals of various intensities on Modified Mercalli scale are drawn (Fig. 2).

GEO-TECTONICS AND SEISMICITY

The northeast India is seismically very active and well known for its two great earthquakes, of 1897 and 1950. From the Seismotectonic point of view the region is very interesting and can be broadly classified into three major geotectonic units.

1. Shillong Plateau-Assam Basin
2. Arunachal Himalaya and Lohit Himalaya and
3. Patkai-Naga-Lushai-Arakan Yoma hill ranges

Figure 3, modified after Verma and Kumar [25], shows the broad tectonic set up of the area. The Assam basin comprises of the vast Brahmaputra valley in the Mikir and north Cachar hills, and the hilly and alluvial terrain in the south, covering the Cachar district in upper Surma valley.

Arunachal Himalaya includes thrusts, faults and overfolding of high magnitudes. The tertiaries, Gondwanas, Bichom group and the metamorphites are regionally disposed in ENE-WSW to NE-SW trend in the Arunachal Himalaya.

The Lohit Himalaya forms the eastern most part of the eastern Himalayan chain. Here, NE-SW trending metamorphic rocks occur along the foothills in contact with Brahmaputra alluvium. Northeast trending thrust belt of Naga-Patkai hills is overridden by the metamorphic belt.

Assam-Arakan basin forms the northern part of an extensive north-south trending geosyncline. The Assam-Arakan region and the frontal folded zone of Tripura and Surma valley forms an integral part of the Burmese plate which moved over the Indian plate during neogene period due to plate movement, resulting in orogeny at the junction of the plates.

The Shillong plateau forms a wedge shaped triangular crustal block, bounded across the Brahmaputra valley by Arunachal Himalaya towards north, Lohit Himalaya towards northeast, Indo-Burma folded belt towards east and south east, Bengal-Burma basin on the south and Rajmahal-Garo-Sylhet gap towards the west. The contact of these geotectonic units with Shillong plateau is marked by conspicuous faults, forming a boundary of the plateau. Towards south and west of this plateau are Dauki and Dhubri tear faults respectively. The Dauki tear fault merges in the east with the Haflong-Disang thrust zone. The complex tectonic regime of the region reveals that the area has experienced great compressive stresses and resulting distortions due to slow northwards and eastward movement of the Indian plate.

The northeast region has experienced many moderate and small earthquakes apart from 1897 and 1950 earthquakes [2, 7] and is frequently shaken by tremors. The seismic activity is high in the Arakan-Yoma region and the depth of foci gradually increases towards the east [25].

Table 1 summarises the epicentre locations of August 6, 1988, as reported by India Meteorological Department (IMD), New Delhi and National Earthquake Information Centre (NEIC) of United States Geological Survey (U.S.G.S.) [20]. The reported earthquake locations fall to the east of the Arakan-Yoma suture, in the Burmese Molasse basin. The epicentre locations given by USGS is based on teleseismic observations. Table 2 lists the after shocks [21] of the event.

Dauki fault represents strike slip/dip slip mechanism and Dhubri fault represents strike slip mechanism whereas, Haflong-Disang thrust is associated with thrust slip mechanism and it merges with Dauki fault towards southwest [25]. The Arakan-Yoma region is characterised by both, thrust as well as strike slip mechanism.

The focal mechanism of Indo-Burma Border region earthquake based on P wave data corresponds to reverse faulting with a moderate strike-slip component.

Fault Plane Solution From P Wave Data

	Strike	Dip	Slip
Nodal plane 1:	290	45	65
Nodal plane 2:	143	50	113

	Plunge	Azimuth
Principal Axes:		
Tension	72	119
Pressure	3	217

The focal mechanism solution as reported by NEIC is shown in Fig. 4. The hypocentre parameters of the centroid locations are obtained by adding perturbations resulting from inversion to the parameters reported in the preliminary listing of the epicenters as released by the USGS.

EVALUATION OF MM INTENSITY

The MM intensity was assigned by analysing the questionnaires which were sent out /distributed by the Department of Earthquake Engineering, University of Roorkee, Roorkee.

Questionnaire

Questionnaire for evaluating seismic intensity at a site contained 22 questions. Several questions were related to the activity in which the respondent was engaged in at the time of the earthquake, and the type of and floor number of the house he was in. All questions in questionnaire were made with Modified Mercalli scale [11,23] in view.

Intensity Assignment

Intensity (V to VII) at various places was assigned as per MM intensity scale [11,23]. Intensity VII was assigned to those locations where little to moderate damage occurred in well built buildings and considerable in poorly built buildings. Intensity VII was also assigned to locations where motor car drivers felt the earthquake.

Intensity VI was assigned to those locations where, dishes and windows were disturbed; objects kept on racks and shelves fell down and slight damage occurred in a few good brick masonry houses, a few instances of fallen plaster were observed and people were generally frightned.

Intensity V was assigned to those places where several people felt the shock, unstable objects overturned, disturbances of trees and other tall objects was noticed and pendulum clocks stopped. The places where the earthquake was felt by a few people and many could not recognise it as an earthquake have been kept in the intensity range IV and below.

RELATIONSHIP BETWEEN PEAK ACCELERATION AND MM INTENSITY

The assignment of an intensity value to the site where the ground motion has been measured is a difficult task due to the fact that the recording instruments are frequently not located near structures which might sustain damage or provide other direct evidence of the local intensity.

From the very beginning of instrumental Seismology, numerous attempts have been made to correlate earthquake intensity scales with peak ground accelerations. One of the first such attempt was carried out by Ishimoto [12] who correlated the horizontal component of peak ground acceleration with six levels of the intensity scale used by the Japanees Central Meteorological Observatory. Subsequently numerous studies have been made to define a functional relationship between the peak ground acceleration recorded at a site and the seismic intensity assigned to that locality [1,8,9,10,13,15,16,24].

In the present study the relation given by Ambraseys [1] has been used. According to this relation

$$\log (a_{hmax}) = 0.36I-0.16$$

where a_{hmax}: maximum horizontal peak acceleration (cm/sec^2)

and I : MM intensity

ISOSEISMAL MAP

Figure 2 represents the delineation of isoseismals as per MM scale. Isoseismals V to VII were drawn by plotting the points where the intensity was estimated and using the observed resultant horizontal peak acceleration values. However, intermediate isoseismals may also be fitted if sufficient data are available. The stations Berlongfer and Diphu had the highest and second highest acceleration (0.337g and 0.331g, respectively). Local geological formations at both the places indicate soil deposit which seems to have magnified the ground motion at these locations. At Saitsama large horizontal acceleration compared to the surrounding stations was recorded. This was perhaps due to local geological formation of soil deposits. However, some stations, even though on thick alluvium and at almost the same distance from epicentre as those at which high accelerations were recorded, did not show the same high acceleration. This might be due to the fact that the attenuation of seismic wave was not same in all directions, which needs further investigation. Keeping in view the local geological conditions [3,5] minor adjustments have also been made while plotting the isoseismals. The elliptical shape of isoseismals with its major axis having NW-SE trend does not show a close association with the existing major lineaments in the region.

The intensity VII was observed at Kamargaon, Diphu, Lumding, Tezpur, Jorhat Jamuguri, Golaghat Phulaguria and Raha where maximum damage occurred. The Assam Tribune, Guwahati of Aug 8, 1988 stated that the earthquake damaged the walls of a large number of buildings including the Assam Agriculture University at Barpeta, Deputy Commissioner's bunglow, Dakbunglow, the post office buildings and several houses of Nairanibari area. The isoseismal VII also covers the places where the peak horizonal acceleration was more then 0.14g.

Isoseismal VI in addition to locations identified through intensity estimates also encloses the places where peak horizontal acceleration less than 0.14g and more than 0.05g was recorded. The regions of Guwahati, Shillong, Silchar, Sibsagar etc. fall in this particular isoseismal. A hotel building caved in by a meter and several houses developed cracks in Silchar while bricks and concrete lumps of a Shiva temple moved away in Sibsagar.

The area bounded by isoseismal V marks the regions of Dibrugarh, Dullabchara, Rambrai, Taipudia, Sarupeta etc. The damage at these places was slight to moderate. The places with peak horizontal acceleration value less than 0.05g have been included in this isoseismal. The regions of Along, Tura, Tripura and Aijal etc. are kept in the intensity range IV and below.

CONCLUSIONS

Salient features of Burma-India Border Region Earthquake of August 6, 1988 and the damage that occurred have been described. Although the earthquake was smaller as compared to those of 1897 and 1950, it caused widespread damage to various structures in the region. Therefore, there is an urgent need to follow earthquake resistant measures more rigoursly while planning new constructions. The elliptical shape of isoseismals with its major axis having NW-SE trend does not show a close association with the existing major lineaments in the region.

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Table 1 Earthquake Parameters of Burma-India Border Region Earthquaqke of 6th August, 1988.

Agency	Origin Time			Geographyhic Coordinates of epicentres		Depth	Magnitude	
	HR	MN	SEC	LAT	LONG	KM	Mb	Msz
IMD	00	35	17.1	25.10N	95.0E	-	-	7.3
USGS	00	36	24.65	25.149N	95.127E	91	6.8	7.2
-do-	00	36	37.6	25.19N*	94.89E			
DEQ				25.392N+	94.533E			

* Centroid location, + based upon strong motion data

Table 2 List of After shocks from 6.8. 1988 to 9.10.1988

Sr.No.	Origin Time (UTC) HR	MN	SS	Date	Epicentre Lat°N	Long°E	Magnitude
1.	06	21	42.3	06.08.1988	25.391	94.97	4.6
2.	13	04	12.3	07.08.1988	25.704	95.218	4.7
3.	16	14	23.1	08.08.19	25.358	24.963	4.9
4.	19	59	50.0	13.08.1988	25.332	94.963	5.0
5.	13	16	28.8	21.08.1988	25.306	95.136	5.0
6.	16	45	06.6	17.09.1988	25.148	95.127	4.6
7.	22	05	03.6	09.10.1988	24.664	94.887	4.5

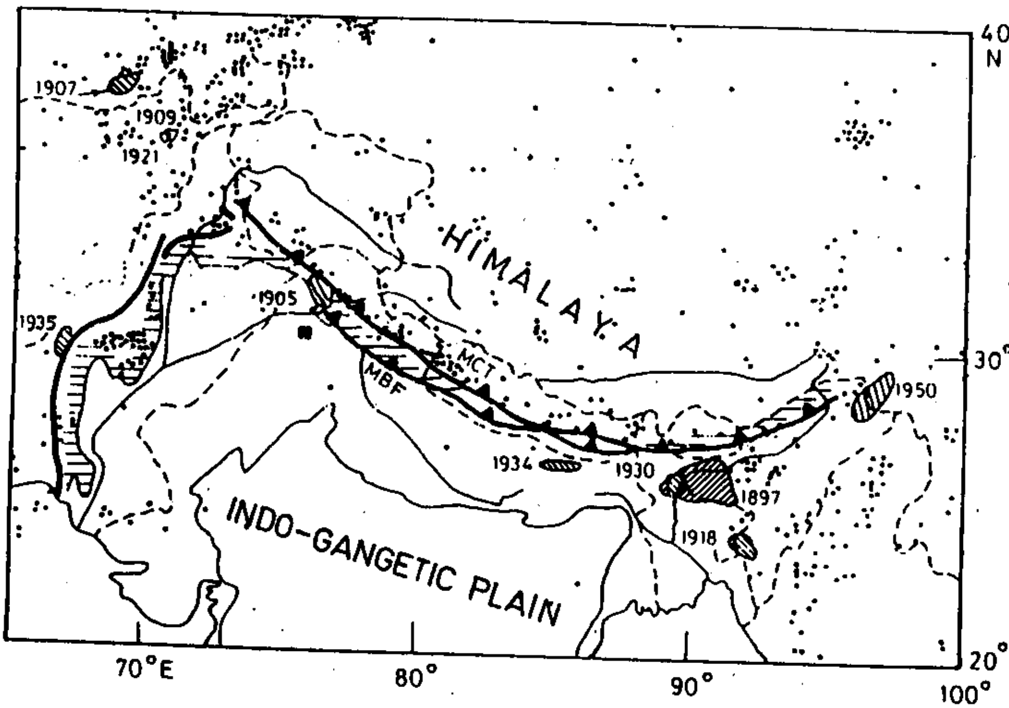


Fig. 1 Megalineaments and Great (including large) Earthquakes in Himalayan region (After Oldham, 1899; Middlemiss, 1910; Auden and Ghosh, 1934; Gee, 1934; Rao, 1953; Gansser, 1964).

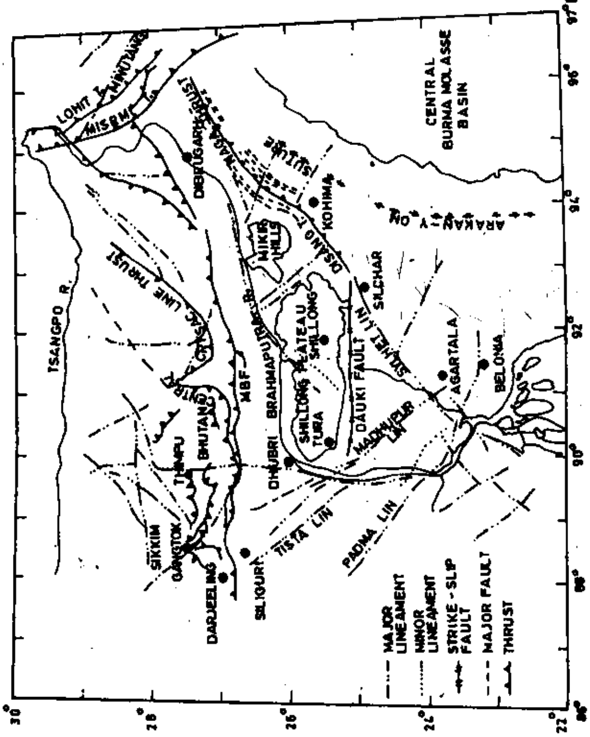
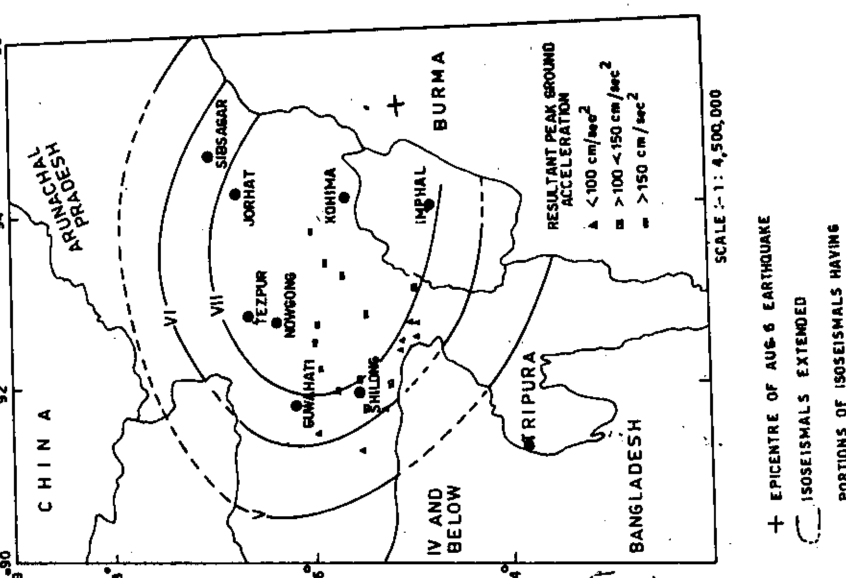


Fig. 3 Broad Tectonic Map of North-Eastern India (modified after Verma and Kumar, 1987).



ISOSEISMAL MAP

Fig. 2 Isoseismal Map of August 6, 1988 Burma-India Border Region Earthquake.

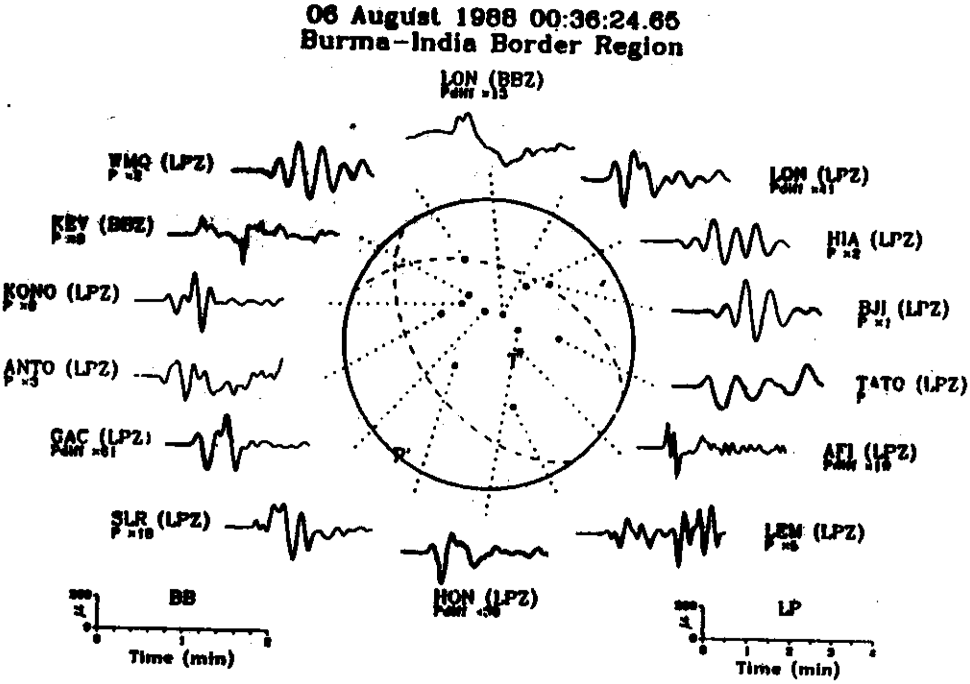


Fig. 4 Focal Mechanism Solution of August 6, 1988 Burma-India Border Region Earthquake.