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Need for intensified seismological studies in northeast India

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ABSTRACT. Of late there has been a keen awareness among scientists, the media and the general public about the vulnerability of NE India to major earthquakes, specially in view of the situation of this region at consumable plate boundaries (according to the Plate Tectonics Hypothesis). The seismological observatory in Shillong has been continuously recording the tremors felt in this region and determining their epicentres, many of which are on the plate boundaries in the Arunachal Himalayas and the Naga-Patko and Lushai ranges. The recent seismological studies by the Regional Research Laboratory at Jorhat (Khazanchi *et al.* 1979) have indicated the possibility of a major earthquake in the region within the decade of seventies. This has led to considerable public concern.

In view of the growing concern about an impending disaster it is imperative that the concerned agencies should take more active interest in seismological studies in this region.

As far as Geological Survey of India(GSI) is concerned its basic function in an earthquake studies programme will include preparation of detailed structural and seismo-tectonic map of the region based on ground survey as well as aerial photo and satellite imagery interpretation, identification of the active fault zones and then evolve some method of continuous monitoring of tremors and movements of the ground in these fault zones. In this task the GSI would act in collaboration with the Seismological Observatory in Shillong of India Met. Dep., the Regional Research Laborabory in Jorhat as well as the Earthquake Engineering Deptt. of Roorkee University.

1. Introduction

It is common knowledge that northeast India is earthquake prone. The region was rocked by devastating earthquakes in 1869, 1897, 1930 and 1950 some of which were of high magnitude ranging from 6-8 on the open ended Richter scale and were classed among the most devastating earthquakes in recorded history the world over. The recent devastating earthquakes in China, Italy, Guatemala, Iran, Turkey and elsewhere have created a renewed awareness among scientists, media and general public about the vulnerability of northeastern region and the need for intensified studies of the seismic factors with the ultimate objective of predicting the major earthquakes.

2. Causes of earthquakes

Most earthquakes occur in certain narrow zones in the earth's crust which join together to form a continuous network which bound areas that are seismically less active. The seismic network is associated with a variety of geological features like mountain belts, rift valleys, volcanic chains, oceanic ridges and trenches. According to the theory of plate tectonics the seismically active areas mark the boundaries of rigid, shifting plates in which the earth's crust is divided. The plates themselves are relatively free from earthquakes. Seismology envisages three kinds of plate boundary, *viz.*, (*a*) the boundaries across which the plates are pulled apart, (*b*) boundaries along which the plates converge and (*c*) boundaries along which the plates slide past each other. Stresses of tremendous magnitude accumulate along these active plate margins and earthquakes result when the stresses accumulate to a point that rocks in the earth's crust break. This violent breakage of the rocks generates seismic waves that propagate through the earth's crust both as longitudinal and transverse waves of different velocities.

3. Seismic setting of northeast India

Northeast India is situated on a converging plate boundary extending from the Mediterranean to Burma (Fig. 1). It consists of a wide diffuse continental zone in which shallow earthquakes are associated with high mountain ranges like the Himalayas that clearly owe their existence to large compressive forces. Earthquakes of shallow and intermediate focus are common along this belt.

Plate tectonics apart, northeastern India is situated in one of the most geologically unstable regions in the world. To the north of the alluvial valley of the *Brahmaputra* through the sub-Himalayan range runs a system of faults known as Main

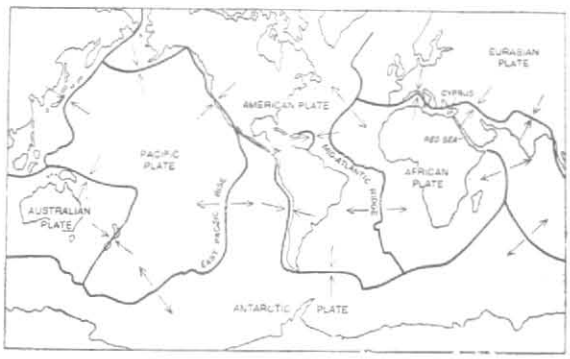

Fig. 1. Six principal tectonic plates of the lithosphere, the rigid and outer shell of the earth, are delineated by the heavy lines on this world map. The paired arrow indicate whether a plate boundary is convergent or divergent. (From *Scientific American*)

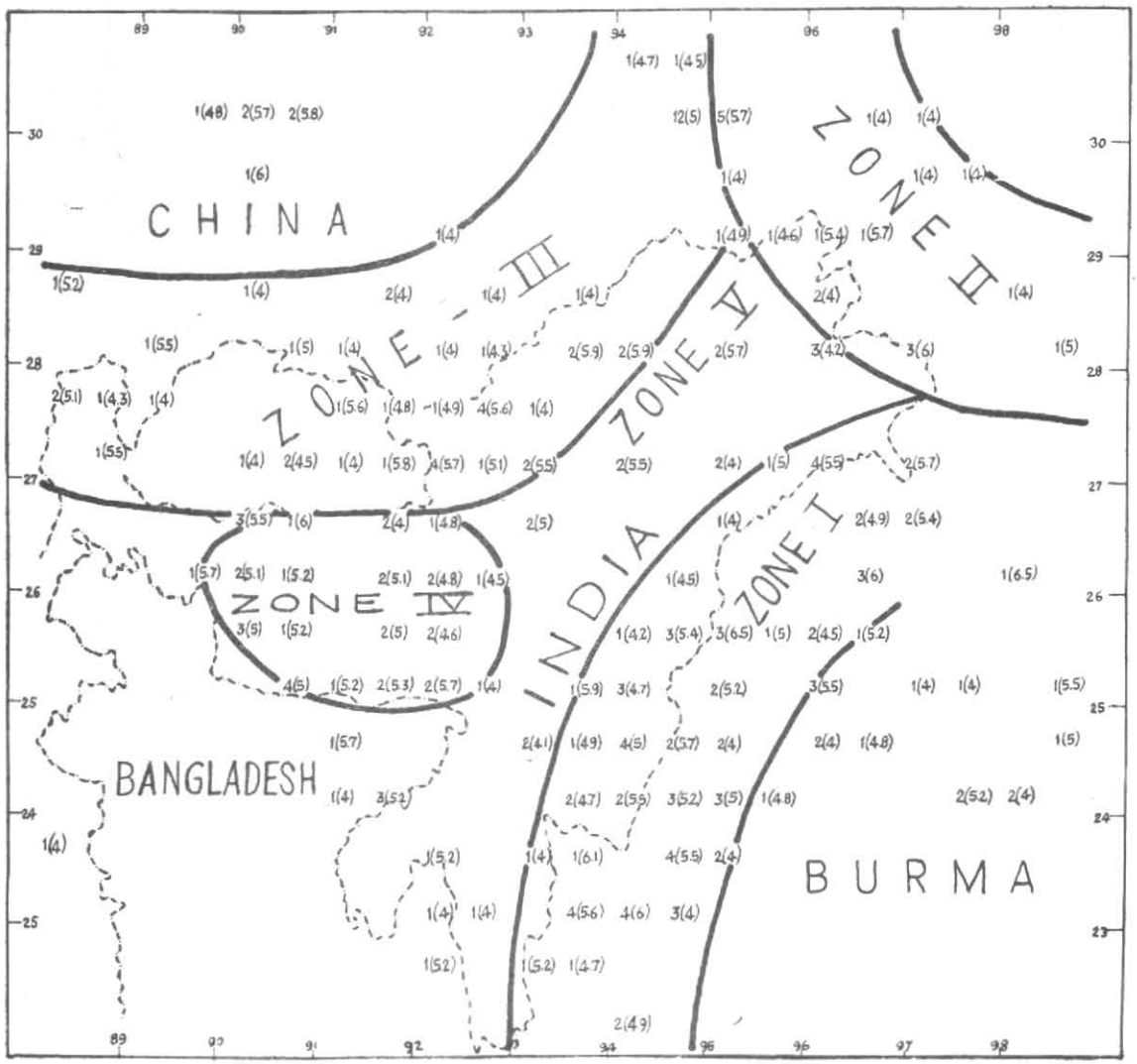

Fig 2. Seismic zones of northeast India. The figures within brackets indicate magnitude on Richter scale while those outside indicate frequency of occurrence.

Boundary Fault. Another fault thrust zone runs east-west along the southern margin of the Shillong plateau and merges with the NE-SW trending thrust zone in Nagaland and Assam known as Belt of Schuppen. Slipping along this E-W fault was the immediate cause of the 1897 earthquake, supposed to be one of the greatest earthquakes ever experienced by man. The Himalayas are still an active orogenic belt and so also the folded geosyndinal belt of Nagaland and Manipur. Recent geological and geophysical studies specially in connection with oil exploration have revealed a number of thrusts and faults which are still active.

4. Seismic zones of northeast India

On the basis of frequency and intensity five seismic zones have been delineated in this region (Fig. 2). Zone 1 which covers parts of Mizoram, Manipur, Nagaland and Arunachal Pradesh is the zone of maximum seismic activity both in regard to frequency and intensity. Earthquake of magnitude 6.5 and above on the Richter scale have been recorded in this zone. In terms of plate tectonics this zone probably coincides with a subduction zone which is more destructive than the 'fossil plate margin' that runs east-west along the Himalayas. However, the epicentres of the catastrophic earthquakes of 1897 and 1950 were not located in the zone 1. This underlines the fact that the destructiveness of an earthquake depends more upon the proximity of the epicentre to the human settlements than on the intensity. Fortunately seismic zone 1 covers areas of extensive jungles with little human habitation as a result of which many severe earthquakes in this zone go unnoticed by the general public.

5. Seismic history of northest India

Proper records of the earlier seismic history of northeastern India are lacking. Satisfactory records began to be kept near about the middle of the 19th century and since then the northeastern region has been subjected to a number of major earthquakes notable among them are those of 1897 and 1950 which are among the greatest and most destructive earthquakes in human history.

A short description of some of the major earthquakes of northeast India is given below :

(1) *1859 : 10 January, Assam (Cachar) :* Felt over an area of 250000 sq. miles. Epicentre north east of the Shillong plateau. Earth fissures and sand craters were numerous.

(2) *1897 : 12 June* —This earthquake was probably the greatest ever experienced by man. The epicentre was in the southern margin of the Shillong plateau on the Dauki fault and the magnitude atleast 8.5 or more. The earthquake was felt over an area of 1.75 million sq. miles. Shillong with its surrounding country was devastated in less than one minute. The vertical component of the seismic motion was so great that stones on the roads of Shillong were tossed in the air. Of great significance geologically are the concomitant structural changes produced on the surface such as fault-scraps, fractures, local changes of level, compression of the ground and slight change in the height of the hills. The most important fault-scrap ran parallel with the *Chidrang* river for 12 miles with a vertical throw varying from 1 to 35 ft, producing a number of waterfalls and as many as 30 lakes in the course of the river. The aftershocks of this earthquake continued for 10 years.

This earthquake is also known to the seismologists all over the world as having laid the foundation of modern seismology. A study of the records of the earthquake led R.D. Oldham to publish his classical memoir in which he demonstrated for the first time that the first two principal phases now designated as *P* and *S* are longitudinal and transverse waves respectively and that these travelled with different velocities along the same path and hence reached the recording stations at different times.

(3) *1918 : 8 July (Assam)* — Epicentre 3½ miles south of Srimangal on the alluvial tract. Felt over 800000 sq. miles.

(4) *1923 : 9 September (Assam)* —Epicentre Lat. 25.5° N and Long. 91.5° E and S-W Assam. Felt over Assam, Bengal, eastern Bihar and Chhotangapur. Caused damage to structures in western Assam and northern parts of east Bengal.

(5) *1930: 3 July* — Epicentre Lat. 25.8° N, Long. 90.2° E near Dhubri near the northwestern end of the Garo hills. Felt over an area of about 350,000 sq. miles. Followed by a large number of aftershocks.

(6) *1932 : 14 August* — Epicentre Lat. 25.8°N and Long. 95.7° E in N-W Burma. Focal depth 130 km (80 miles). Some damage over eastern part of north Assam. Felt over Assam, Bengal and north Burma.

(7) *1941 : 21 January* — Epicentre Lat. 27.5°N and Long. 93.5° E in north Assam. Felt over Assam and north & east Bengal.

(8) *1943 : 23 October* — Epicentre Lat. 27.5°N and Long. 93.5° E in Assam. Felt over Assam, Bengal and major parts of Bihar and northeast Orissa.

(9) *1947 : 29 July* — Epicentre Lat. 28.5° N, Long. 94°E in NE Assam. Felt over Assam, Bengal and northeast Bihar. Damage in NE Assam.

(10) *1950 · 15 August* — This earthquake is regarded as one of the greatest earthquakes in human history both in magnitude (about 8.5 on the Richter scale) and destructiveness. The area suffering most extensive damage in life and property was 15,000 sq. miles including the districts of Lakhimpur, Dibrugarh and Sibsagar of Assam while the area of less damage was nearly 75,000 sq. miles. The earthquake caused all the usual surface effects, huge fissures discharging sand and water, subsidence of the ground in some areas and elevation in other tracts, altering the drainage of the country and causing extensive floods. After a few days these floods were greatly accentuated by the bursting of numerous temporary dams caused by landslide in the courses of *Dihong*, *Subonsiri* and other tributaries of the *Brahmaputra*. Changes in the main drainage lines including that of *Brahmaputra* has caused the problem of bank-erosion as a result of which part of Dibrugarh town has been destroyed. Landslides of great size scarred the hill ranges around northeast Assam disrupting the drainage of innumerable streams inundation of which swept the countryside for months after the quake. According to official estimates 1522 deaths occurred with floods taking heavier toll than the earthquake. Besides, thousands lievestock perished and nearly 80% of the houses in Dibrugarh and Sibsagar towns were damaged or destroyed.

The epicentre of the earthquake, determined by the seismographic recordings in India, United States and France was about 200 miles north of Sadiya in the Mishmi hills region of Arunachal Pradesh.

6. Need for intensive studies

In view of the growing concern about the high seismicity of northeastern region and specially about an impending disaster it is imperative that the concerned agencies should launch a programme of integrated studies of the factors responsible for the high seismicity of the region with the ultimate objective of making fairly reliable prediction of impending major earthquakes.

As far as the Geological Survey of India (G.S.I.) is concerned the following aspects of study are proposed to be taken up on a detailed and systematic basis :

(1) Preparation of a detailed structural map of the region based on ground survey, aerial photo and satellite imagery interpretation.

(2) Preparation of seismo-tectonic maps and seismic zoning maps.

(3) Identification of active fault zones in the region and then evolve some methods of continuous monitoring of tremors and movement of the ground in these fault zones.

(4) Study of the tectonic environments and site conditions of major project sites and study of surface breaks or evidences of other recent movements in these areas.

The Geological Survey of India, North Eastern Region, proposes to create the necessary organisational arrangement for systematic study of the geological factors of seismicity of the region in which experienced structural geologists, geophysicists, photogeologists and remote sensing experts will be associated. In this task G.S.I. will act in collaboration with the Seismological Observatory in Shillong of the India Meteorological Dep., Regional Research Laboratory in Jorhat as well as the Earthquake Engineering Dep. of Roorkee University.

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