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The Seismicity Of North East India- Its Strain Release, Accumulation And Potentiality And Seismic Indifference In The Assam Gap: An Analysis

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Abstract: North-East India (N.E. India) is highly earthquake vulnerable area surrounded by the Himalayas, Arakan Yoma, Hills and plains of Bangladesh, etc. it falls within the zone V of seismic intensity and one of the sixth active zones of the world. Its earthquakes are all of morphometric mainly due to collision between India and Chinese plates in the north and Indian and Burmese plates in the east and south and due to local rift and fault displacements that criss-cross the whole region. The region has the highest strain release in 1897 and 1950 based on which it may be observed that the strain is somehow gaining accumulation here day by day and increase the seismic potentiality of a great earthquake to be occurred in near future. Again from isostrain map, it is to be noticed that the valley part of the Brahmaputra & Barak and the Shillong Plateau have the high accumulation strain and low release of strain. Assam Gap zone named by Kayal as Aseismic Corridor has the lowest release of strain or almost nil is becoming a mysterious zone for the seismologists and apprehension of presence of future strong epicenter in this zone is increasing.But two zone shows no reaction to the morphotectonics of the region except few in the long history and the sign of future presence of epicenter in this zone is still remain uncertain as per theory and applied seismological sciences. North-East India may be divided into six seismotectonic zones as Eastern Himalayan Collision Zone, Indo-Myanmar Subduction Zone, Syntaxial Zone of Himalayan Arc and Burmese Arc (Mishimi Hills), Plate boundary Zone of Tripura-Mizoram Fold belt and the Aseismic Corridor or Asaam Gap Zone.

Key words: Seismicity, Morphotectonics, Aseismic Corridor, Seismic Potentiality, Strain Release, Strain Accumulation, Assam Gap.

1. INTRODUCTION

N. E. India is highly tectonically sensitive zone where mountains and valleys are of very recent origin. The Himalayas in the north is existing over the collision zone of two plates under viz. the Indian Plate and the Chinese or Asian Plate and the Arakan Yoma in the east is over the subduction zone of the Indian Plate and Burmese Plates. It is an arcuate zone of plate consumption where in the north, the plate collide at the rate of 5.5 cm/yr (Minster and Jordan, 1978). The region has been experiencing a long history of earthquake occurrence having both high magnitude and high frequencies. These are believed to occur due to its high complexities in morphotectonics. Seven high magnitude earthquakes occurred during the last 100 years as for example having magnitudes 7.5 in Cachar (1859), 8.7 in Shillong (1897), 7.6

in Assam (1918), 7.1 in Dhubri (1930), 7.2 in North-East India (1943), 7.9 in Main Boundary Fault (1947), 8.7 in Indo-China border (1950) and 7.2 in Indo-Myanmar border (1988).

Objective

The main objective of the study is to analyse the seismicity of North East Indiain terms of Strain Release, Accumulation and Potentiality & Seismic Indifference in the Assam Gap.

Database and Methodology

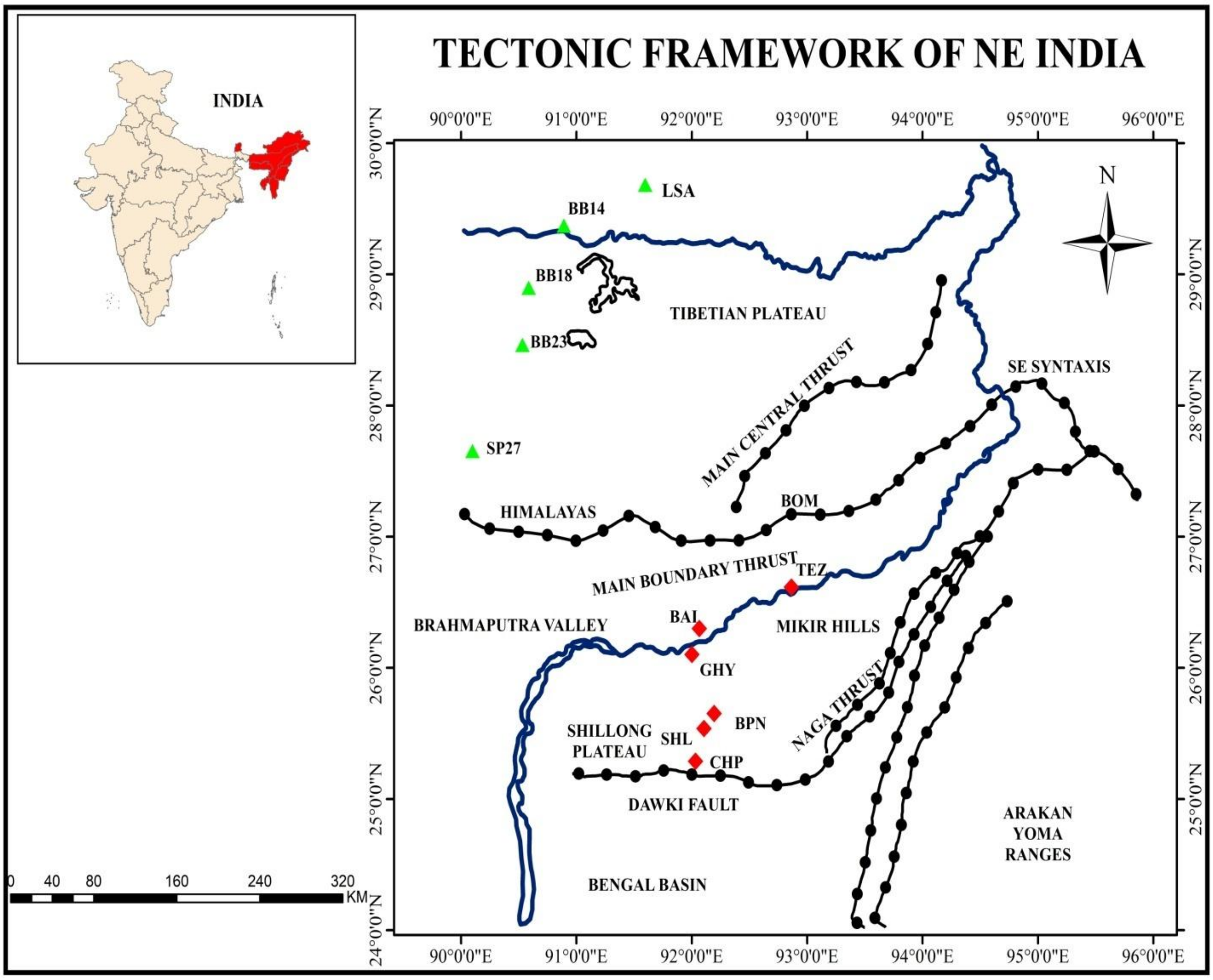
The present study have been done using secondary databases in respect of journals, books, Ph. D, M. Phil Dissertations and monographs with a view to develop a broad theoretical framework of the work. For mapping purpose Geographical Information System has been applied.

Review of Literature

Seismicity in North-East India is studied by many seismologists as Chouhan et al. (1966). Tendon and Srivastava (1976), Verma et al.(1976), Kaila et al., Guha et al. (1984), Khattri and Wyss (1975), Arun Bapat, etc. on many fields.

Morphotectonic and Geo-tectonic framework of North-East India

The Himalayan mountain of recent origin in the north, Shillong plateau, Karbi Anlong and Barail range in the middle, the Patkai-Arakan Yoma in the east and south-east exhibit a congested mountain-valley-plateau combined complex physical as well as geotectonic framework of the region (fig: tectonic framework map). The valley, mountain and the plateau are bounded by faults, thrusts etc. as the great boundary fault in the south of the Himalayas and the north of the valley, steep fault in the north of Shillong plateau bordering the Brahmaputra valley, the Dauki fault in the south of the Shillong plateau (dextal transcurrent fault by Evan, 1964 moving 250 Ian towards east), Naga thrust east of Shillong Plate – syntaxial bend and faults in the east by Himalayas and Arakan Yoma in the north-east Valleys have crustal shortening to the extent of 150-300 Ian (Evan, 1964). Geology of the valley is alluvium above, 4-5 km thick tertiary rock in the middle and the pre-cambrian basement rock in the below- extending from Karbi Anglong and Shillong Plateau. Indian plate is dipping northward that is evident from earthquakes occurred uptill now (Fitch, 1970; Molner et al. 1973; Rastogi, 1974; Das and Filson, 1975; Tandon and Srivastava, 1975; Chauhan and Srivastava, 1975; Chanda, 1978 and Srivastava and Chowdhury, 1979). In the east , Arakan Yoma is characterized by fault thrust and strike slip; dauki fault is Thrust faulting in E-W trend-all indicate the northward movement of the whole landmass and the lithosphere under eastern Himalayas, Assam Valley and Shillong Plateau is still rising. Indo-Burma border faults and geological structures are all in north-south direction. The pressure and tension axes plunge nearly parallel and perpendicular to the trend of the mountain range (Ichikowa et al., 1970). The important fault and lineament over which the epicenter exists are Jamuna fault, Main Boundary fault, Dauki fault, Kapili lineament and Brahmaputra lineaments.



Seismicity: The seismicity may be studied in two directions.

Spatial: The seismicity of N. E. India follows the following characteristics:

1. Seismic epicenters in N. E. India follow the line of major faults, thrusts and lineaments- JF, MBF, KL, BHL, etc.
2. Concentration areas are whole of Manipur and south of Nagaland and most active. The areas extended between 92^0-93^0E& $26^0 21^/$ N and the middle part of the Shillong Plateau are more active. Western part of Tripura is active due to aftershock of 1950 great earthquake. Southern part of Meghalaya (where 1897 earthquake occurred) and Assam Gap have practically absence of seismicity and the area between Shillong Plateau and Karbi Anglong are less active.

Temporal: Space –time plotting study from the Shillong Plateau and other region, it is not that the major earthquakes decrease after last part of seventies, but small earthquakes are increasing in number, of course, there is the limitation of availability of data. There was a quiescent period of seven years before 1950 great earthquake may raise question which signifies the strain accumulation beneath. The highest earthquake frequency of occurrence was during 1950-51 and 51-52 but the frequency of occurrence around 1897 when the highest magnitude earthquake occurred was not as high as that occurred after one or two years of1950's earthquake. Now the frequency decreases which may indicate the accumulation of strain.

Strain Release and Accumulation Study: The strain release may be studied in the light of the Gutenberg and Richter (1956) method.

1. $\text{Log}\sqrt{E} = \sqrt{(11.8 + 1.5}$Ms) for surface wave
   Where E= Energy, Ms=magnitude
2. $\text{Log}\sqrt{E} = \sqrt{(5.8}$+2.4mb) for body wave
   Where E= Energy, mb=2.5+0.63 Ms
   So, $E^{1/2}=10^{(5.8+2.4mb)1/2}$
   $=10^{2.9+12mb}$

With these methods, the energy release is studied from the N. E. India within 25^0 N to 29^0 N and 93^0 E to 97^0 E area and major earthquakes that occurred in N E. India are also included and incorporated in the study (fig:strain release curve, based on earthquake date 1846-1993). We must consider N. E. India as single regional entity and great earthquakes of 1869, 1897, 1906, 1908, 1918, 1923, 1930, 1931, 1943, 1949, 1950 and 1988 that occurred in different parts of N. E.India are to be considered. The study reveals that the strain was gaining before after 1950 in the whole region. From the earthquake strain release graph, it is noticed that there are 4 periods of maximum earthquake activities (a, b. c, and d) and 4 periods of stress accumulation (A, B, C and D) before 1950. The present ongoing earthquake period will have a "e" point elsewhere of maximum activities and a "E" point of maximum stress accumulation towards right-hand side. From the graph, it is also noticed that the length of quiescent period increases with the increase of time and the increase of maximum stress accumulation and release. So far record is available, the maximum activity years are 1846, 1869, 1897, 1950 and the years of maximum stress accumulation are the years just before the years of maximum earthquake activities. The periods of maximum stress accumulation are before 1846, 1846-1869 (23 years), 1869-1897 (28 years), 1897-1950 (53 years) and 1950 onwards. So the gap periods are 23 years, 28 years and 53 years. The gap period increases first by 5 years and second by 25 years (5 times than the previous year) and it may be

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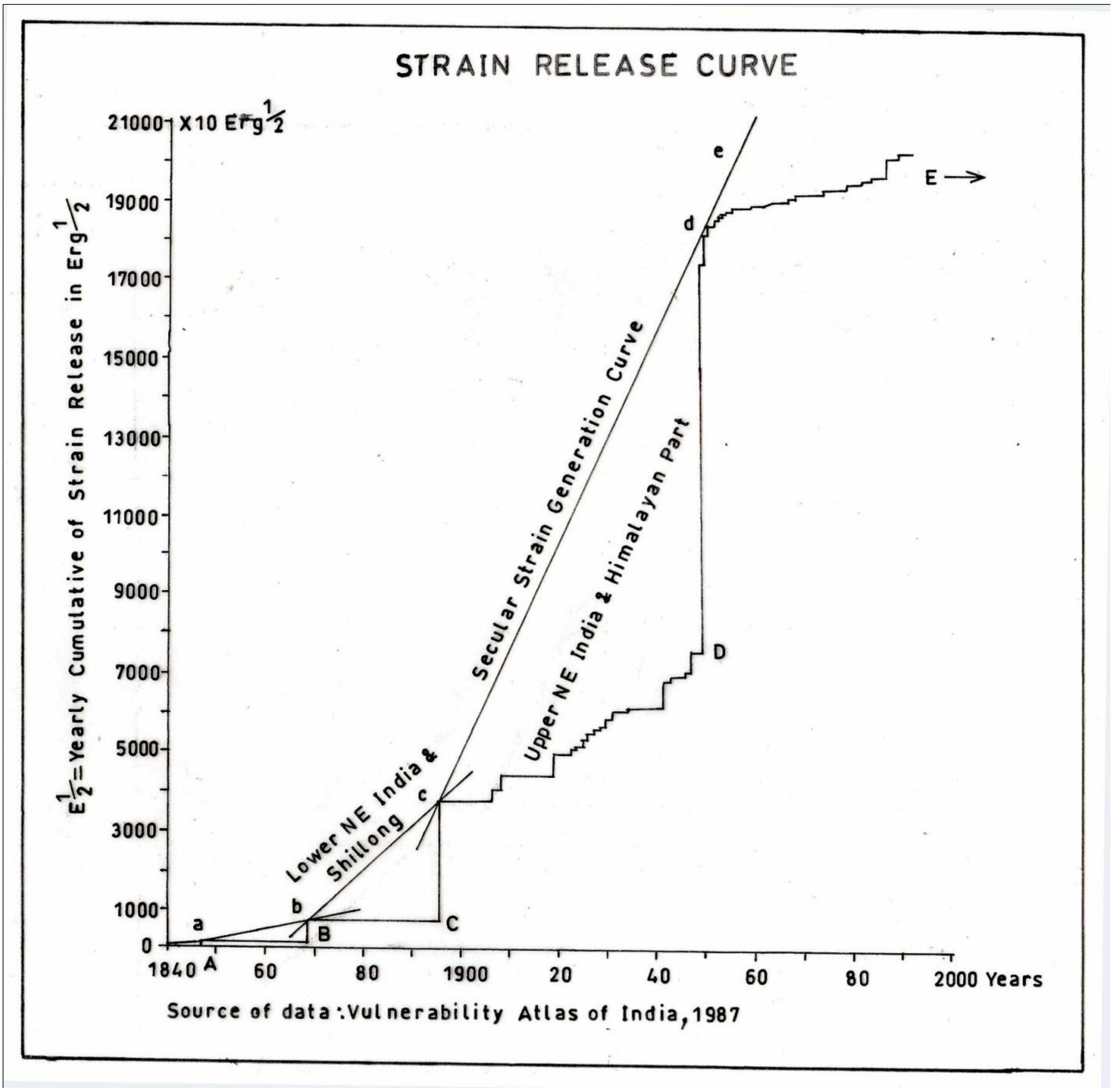


envisaged that the ongoing gap may not be less than 125 years (5 times at minimum as the previous one). But it is not a problem of mathematics or statistics, but depends on the actual reality. The volume of stress accumulation and released is tremendously increasing with the yearly rate, but the geometric rate of progression (number of time increased than the previous ones) is decreasing with the increase of time- e. g. 1846-68 (8.6 times), 1869-97 (5.2 times), and 1897-1950 (4.6 times). Again it is noticed that the aftershocks last for long time- for many years may be. The yearly individual release of stress may be noticed as follows:

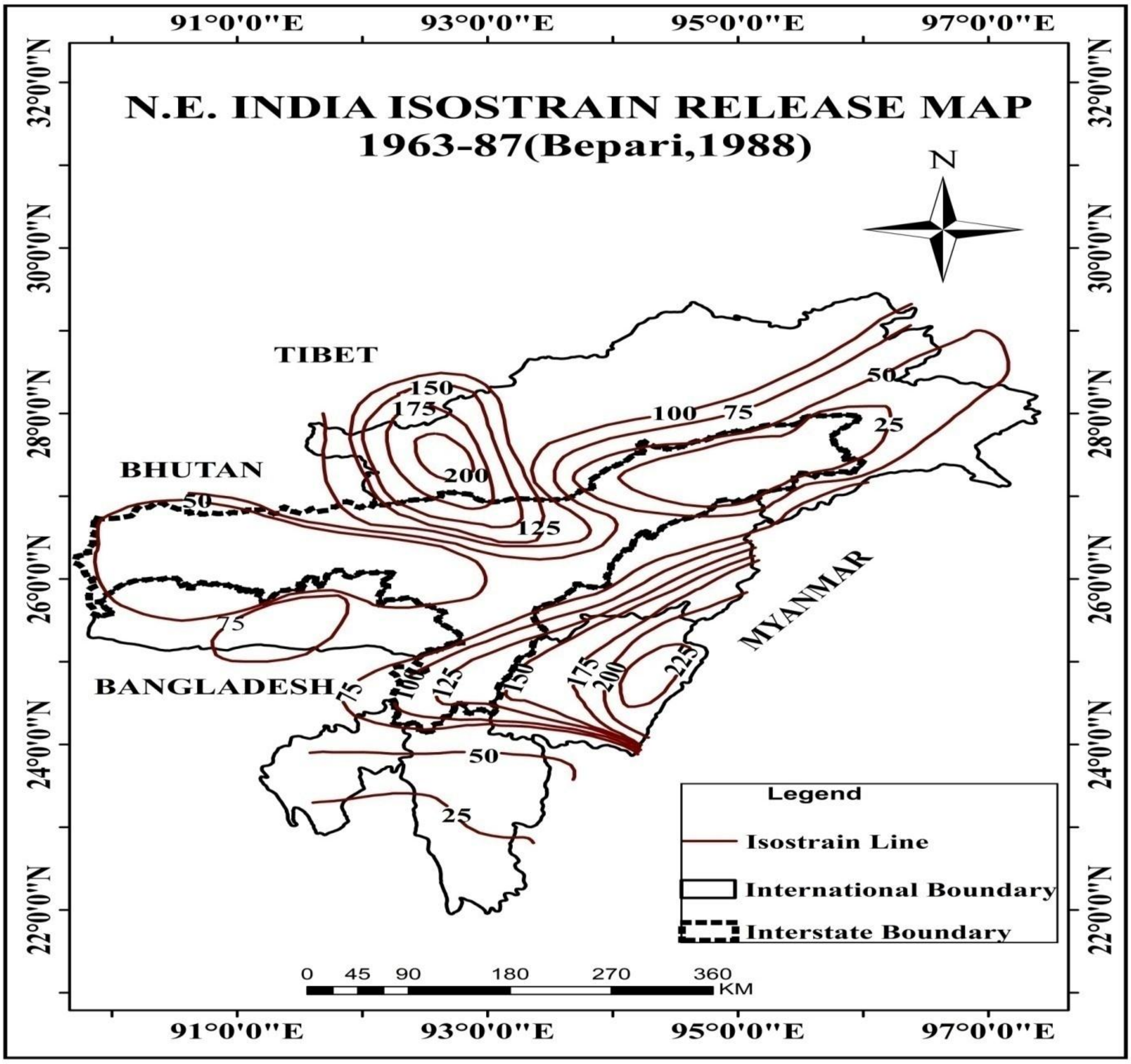
1846 - 82 ergs$^{1/2}$

1869 – 626 ergs ½

1897 – 3000 ergs ½

1950 – 9863 ergs ½

Study on isostrain map of recent years exhibits that the strain release is maximum in whole of Manipur, south-east Nagalad, western part of Arunachal Pradesh and release is minimum in Upper Assam, Karbi Anglong upto south-east of Shillong Plateau (fig: isostrain release map). The valley part of the Brahmaputra has the lowest release of strain throughout history or it is a domanat basin which has very less number of epicenters within it.



b Values:

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The study of b value indicating stress condition also may be of some indicators about the impending earthquake. b value may vary from time to time and if it is found high, there is the release of stress and when decreases, the stress increases. During aftershock time of major earthquake, b values are found slowly increasing and during foreshock time b values are found smaller. b values vary from 0.5 to 1.0 for tectonic earthquake and larger values are for volcanic earthquakes. From the studies of b values (Bepari, 1988), it is found ranging from 0.25 to maximum 1.43 having some 3 periods of ups and downs during 1963 to 1987 with 1975 at minimum. Where b values are minimum, it indicates the earthquake may come soon. Sudden up and down of b values will indicate instability in stress and increasing of stress.

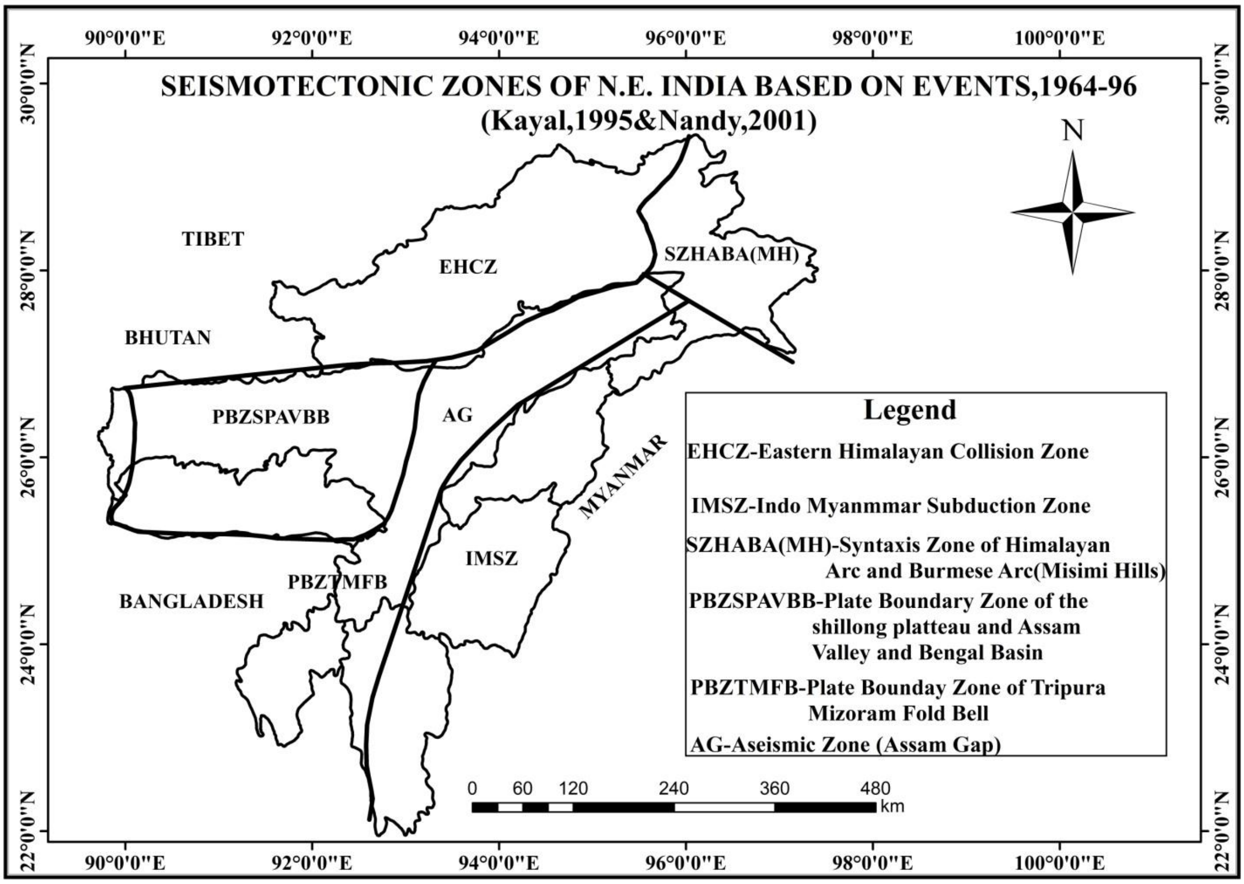
The Assam Gap:

The Assam Gap (Khattri et al. 1983) may be a region of accumulation of strain. But it is not behaving usally as we assume. The Assam Gap is located $25^{0}5^{\prime}$ to $28^{0}45^{\prime}$ N and $92^{0}5^{\prime}$ to $95^{0}5^{\prime}$ E (Khattri and Wyss, 1978). The Assam Gap is defined as region where earthquake activity is less corresponding to neighbourhood areas along plate boundaries (Srivastava, 1978). The Assam gap (Khattri and Wyss, 1975) is lying between rupture zone of 1897 and 1950 earthquakes in Assam, formerly known as seismicity gap (Fedotov et al. 1970; Kellehar, 1970; Sykes, 1971) extends for 400 km (previously) but later on due to demarcation of boundary by liquefaction and slides and Kapili asperity, the length is reduced to 240 km (Khattri et al., 1983).

According to Khattri et al. two criteria are there regarding gap:

1. The segment is a part of the major seismic belt characterized by strikeslip or thrust faulting,
2. Not ruptured for at least 30 years.

After 1943, no earthquake epicenter is located in the Assam gap. There are six grades of gap region having different seismic potentiality. The highest one is categorized as no. 1 and in this way; higher values are given up to six to mean less to lesser potentialities. The Assam Gap is assigned to category 2, because it experiences only 1 large shock (epicenter) in the past 30 years ago but less than 100 years ago. The region except western part is in quiescence for sufficiently long time. According to Kanamori (1981), though earthquakes are preceded by a period of quiescence, but it does not necessarily indicate an impending great earthquake. This type is not found similar to Japan’s doughnut pattern (Mogi, 1979) or swarms (Evision, 1977; Wyss et al., 1978) or foreshocks (Ishida and Kanamori, 1977; Jones and Molner, 1979), and decrease in activity (Ohtake et al., 1977). So this region, though has high potentiality, but is uncertain regarding the time of occurrence of great earthquake in future and so cann’t be forecast (fig:seismotectonic zones map).



Micro-Zonation of Earthquake in N.E. India:

Kayal (1996) and Nandy (2001) have divided N. E. India into five seismotectonic zones based on distribution of epicenters, fault-plane solutions and geotectonic features. These are-

1. Eastern Himalayan collision zone.
2. Indo-Myanmar subduction zone.
3. Syntaxial zone of Himalayan arc and Burmese arc (Mishimi Hills).
4. Plate boundary zone of the Shillong plateau and Assam valley.
5. Bengal basin and plate boundary zone of Tripura-Mizoram fold belt.

The Assam Gap may be isolated from Shillong Plateau plate tectonic zone. So it will be consisted of as sixth zone (fig:seismotectonic zones map).

2. CONCLUSION:

It is noticed that as the accumulation of stress between 1897 and 1950 was growing, the stress is also gaining after 1950 which finds rare chances to release. The accumulation and released volume of stress increases tremendously with the increase of time. The observation into the gaps between earthquake events brings into light that as the gaps increased with the increase of time, now it may be felt that there is no possibility of occurrence of a great earthquake soon. Again the Assam Gap though is having tremendous possibility of the occurrence of a great earthquake, yet it remains as uncertain regarding occurrence or the time of occurrence. The study of b values indicates the accumulation of stress and possibility of early occurrence of a great earthquake. But the forecasting systems are yet to get maturity in this region which to be taken care of with definite fruitful technology and effective methods.

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