Chapter 2

PATTERN, DISTRIBUTION & CAUSALITY
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In dealing with earthquakes of old date he also needs a knowledge of history, proper interpretation of developments may call for the help of professional historians

— C F Richter

The historical evidences from north east India provide us fairly accurate account of the tremors, at least of the grave ones, since Ahom rule. The Ahom chronicle Buranjis mention large number of quakes that devastated the region during that period. With the entry of the British, we began to get a detailed and scientific account of the earthquakes, as their scientific advancement enabled them to make detailed study of the earthquakes in the region. The above two

1 Richter, C F. Elementary Seismology, pp. 5.
records thus enhance the opportunity to report the earthquakes of the region almost without any break till the end of the study period.

**PRE-COLONIAL PERIOD**

Ahom entered the region in 1228 AD and gradually established their rule over a considerable area of this region. Thus an Ahom state not only got established but Ahoms also ruled over a great part of the Region for a long period of six hundred years till almost the arrival of the colonial rulers by 1826. One very distinct feature of the Ahom state was that, it was quite serious so far as the keeping of records were concerned. It was the royal chroniclers of this kingdom, who kept a detailed record of the Ahom Rule of this six hundred years almost in a book form under the title ‘Burunjis’. These Burunjis, while reflecting a very developed sense of history on the part of Ahoms have left a store house of information about the Ahom State including the various natural calamities which the State had faced during its existence.

There were a few tremors which not only caused collapse of buildings but also water, sand, fish had been found thrown up from below. The earthquakes in 1548, 1595, 1607, 1649 and 1696 are noteworthy.

There were several earthquakes in the year 1642, which were followed by a heavy flood in that year. On the 7th February 1663 a severe earthquake occurred which lasted for about half an hour.

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During the reign of the King Ruddra Singha (1696-1714) another great earthquake occurred in this region. Though determination of epicentre started quite late with the beginning of the instrumental seismology (i.e., the study of earthquake) by the end of nineteenth century, certain intelligent guesswork about the location of those major earthquakes of Ahom period could surely be made from the area-wise extent of damage. Thus, regarding location of epicentres of these shocks, one opinion is as under:

But from the account of damages, it may be surmised that the locations of these earthquakes were not very far away from the Brahmaputra Valley.

As we shall see, while identifying the seismic status of a region it is not mere location and frequency, the third very important factor the magnitude, i.e., the size of the earthquake plays a very significant role. Regarding magnitude of all these historical earthquakes of this region there is a distinct remark made as below:

Although mention has been made of a number of historical earthquakes, specially to those of the pre-British period. However, the severity of damages caused by them indicates that they might have been earthquakes of large magnitudes.

In the pre-colonial period there were, if not large, at least one more major earthquake that shook the tectonic zone of North East India. The earthquake of April 2, 1762 which had though been identified as one from Aracan, its origin was from a place which would

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5 Ibid.
6 Ibid.
certainly form a part of overall seismic source zone of the region and hence already been taken to be a part of earthquake catalogue of the N.E. Region.\textsuperscript{7}

Thus, when the entire period of Ahom rule is considered the available records about earthquake starts with that of 1548. The earthquakes those follow are in 1595, 1596, 1607, 1642, 1649, 1663, 1696 and 1762.\textsuperscript{8} From the record itself it is seen that from 16\textsuperscript{th} century onward not a single century is devoid of at least two major (if not large) earthquake so far as the Assam is concerned, than why the Ahom record is silent about any of the earthquake during the first 300 years of their rule in the region? It is true, science of seismology is yet to trace a definite trend so far as the occurrence of earthquakes are concerned, so that, one can claim with certainty that there should have been an earthquake, but from the most likely trend of happenings of the seismic shock in the region, it seems most unlikely that from 1228 to 1547 the region could be free of any seismic event of significance. In all probability the writing of Ahom chronicle started much after the settlement of Ahoms in Assam. Further, there were no question of destruction of Ahom properties out of an earthquake till their capital was established and a number of constructions made. Population being also too scattered and scanty, earthquakes had little impact on the Ahom kingdom and hence the omission. Initially Ahoms

\textsuperscript{8} \textit{Ibid.}, p. 354-355 & Gogoi, Lila, \textit{op. cit.}, p. 232.
had to face the problem of flood in the region, which find distinct mention in the Buranjis. In 1228 AD Sukapha, the founder of Ahom kingdom in Assam arrived in Khamjang. From there he went to Mungklang Chekhru (Abhaypur), where he stayed for several years but had to shift again to Habung in 1240 due to flood. In 1244 a heavy flood necessitated another move and Sukhapha reached Simaluguri via Ligirigaon. All these information are very much a part of Buranjis.

In addition to all above, while establishing this region, Ahoms were very deeply engaged in wars for about initial three centuries and it would be most like that the chroniclers attention were drawn towards those priority events. Non-availability of earthquake records in the Buranjis (so far unearthed) for the initial over three hundred years might have been the result of those complex events of consolidation years. A part of the records also might have been destroyed during Maomarih rebellion.

**COLONIAL PERIOD**

With the onset of colonial rule, nineteenth century onwards, status of earthquake records in the region had improved. The earliest recorded earthquake of the 19th century was of 1810. It happened on 1st April when "two shocks, very distinct, quick appeared first from north east to south east and then from the opposite. Duration 6 seconds and 30

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9 Gait, E. op. cit., p. 73-74.
seconds each. Felt very distinctly at Garden Reach, close to Calcutta, the accompanied shock said to be like muffled belts, felt also at Dumdum, Barackpore, Murshidabad, Ramnagar etc. It is evident that these shocks were reported from Calcutta and did not mention the north east. But the direction of the tremor that visited Calcutta was from "north east to south west" which did suggest that the place of origin of these shocks were somewhere in the north eastern region of India though identification of exact location would be difficult. Similar tremors were felt during 12th to 15th May, 1816 "several shocks, last one severe" had rocked the region, which were recorded at Rangpore. However, it did not mention north east India. Rongpore was on the frontier of north east India, therefore, it could be safely assumed that the quakes had its centre of origin in north east India. This report did not detail the destruction it caused. But the narration described the shocks as a "Swarm phenomenon". In the year 1819 a number of earthquakes have been reported from 'Gowhatty' (Guwahati), Jagee (Jagiroad) and Barpeta of Assam. In the morning of 22nd January, 1819 a sever shock was reported from 'Gowhatti'. As reported the shock was felt after a very long interval. "All who were in houses at the time describe the shock as one of the severest one ever had, and the rumbling as extra-ordinary load". The shock was

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11 Ibid.
* when a long series of large and small shocks visit an area with no one surpassing the principal event it is generally called a Swam Phenomenon.
felt at Ruha and Nowgang also. At Ruha it lasted at least a minute, the ground moved greatly, the trees also shook violently but no damage of building was reported. Three distinct shocks of earthquake were felt on 22\textsuperscript{nd} January, 1819 at Barpetah at around 8 am. These were from the north. On 23\textsuperscript{rd} January, 1819 also Barpetah felt one more smart shock at around quarter past 11 pm apparently from the north. On 23\textsuperscript{rd} January, 1819 at 9 pm another strong shock was also reported from Jagu (i.e., present Jagiroad). In 1819 on 26\textsuperscript{th} January at 5 am Jagee was again rocked preceded by a rumbling noise like the movement of heavy guns. However, earth movement was not so violent as those of 22\textsuperscript{nd} and 23\textsuperscript{rd} described above.

Captain Dalton also recorded the shock at 'Gowhattty' (Guwahati) along with certain peculiar observations:

\begin{quote}
We experienced here on the morning of the 26\textsuperscript{th}, two shocks of an earthquake, which were very remarkable, not so much for the violence of the shocks – for that was nothing to signify but for the loud noise that preceded, accompanied and was heard some seconds after the trembling had eased. There could be no mistake as to whence the noise proceeded. I heard it distinctly two or three seconds, before there was any sensation of a shock, gradually approaching and for some seconds after it had passed, and it distinctly notified the direction of perturbation and gave me a vivid idea of the rapidity with which it moved.
\end{quote}

\begin{flushright}
13 \textit{Ibid.}
14 \textit{Ibid}, pp. 175.
16 \textit{Ibid.}
\end{flushright}
But earthquake that took place on January 3, 1825 was distinctly recorded at Gauhati.\textsuperscript{18} It was also noticed that the direction of the shock wave was from eastwards.\textsuperscript{19} The centre of this seems to lie on the east and south-east-Indo-Myanmar border, which is an active seismic zone.

After this event, we begin to get detailed description of the earthquakes in the region. As it is evident from the report on the quake of January 5, 1825 recorded "two shocks, first at 7 pm, second at midnight"\textsuperscript{20} in Mymensingh, which though politically situated within Bengal (present Bangladesh), in reality is a part of the seismic domain of north eastern India. After three days, i.e., on 8\textsuperscript{th} January, 1825 another tremor was felt in Mymensingh. T Oldham records gentle (shocks) felt at first, severe afterwards, apparently from the north.\textsuperscript{21} AT around 6.50 pm four shocks were felt at Comillah and the last one was reported to be severe. Mymensingh was again rocked on July 8, 1828 at around 2 pm, there were three shocks from north to south followed by another one 12 minute later.\textsuperscript{22} The same shocks were felt at Sylhet too around the same time, as both the districts were adjacent to each other. Shillong plateau is located on the north of Mymensingh and even further is the Himalayan region. Therefore, the

\textsuperscript{18} Oldham, T., \textit{op. cit.}
\textsuperscript{19} \textit{ibid.}
\textsuperscript{20} \textit{ibid.}
\textsuperscript{21} \textit{ibid.}
\textsuperscript{22} \textit{ibid.}
origin of these shocks must be either at the Shillong plateau or in the Himalayan frontier of North East India.

The hill tracts of Chittagong was rocked on December 15, 1830 at about 4.50 pm. Three fast succeeding shocks were felt with a loud noise from southwards. The area was rocked again 15 days later on December 31 at about 2 am. It was indicated that shocks were persistently felt during the next fifteen days, thus constituting a swarm.

The other earthquake in the region, rocked Rongpur again in 1834 (July 21). This time the shocks caused the formation of fissures on the ground, from which smokes and flames was discharged and following that the fissures were closed. This was an major seismic event because no major quake was reported from Dhubri until 1930, which was almost one hundred years hence.

In 1839 (January 14) quakes were reported from Sadiya in upper Assam which was "preceded by rain and heavy snow" which rendered it very cold. Sadiya was rocked again on June 3 the same year which was accompanied by an unusually wet climate from March onwards.

In 1840 two low intensity shocks were felt in January 14 and February 3, both at Nazira in upper Assam. In March 4, 1840, Sadiya

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23 Ibid.
24 Ibid.
25 Ibid.
26 Ibid.
27 Ibid.
was rocked continually. Interestingly before this quake there was a total eclipse of sun about an hour before the quake during which the air was "usually cold and disagreeable".\textsuperscript{28} Gauhati was rocked on February 9, 1841 with tremors which were "sharp and stunning as if a blow had been struck under the jaw".\textsuperscript{29} During 1841 the earthquake was reported from Nazira again. 1842 was reported with quakes, the first one being on January 4, when "a smart shock, undulatory" was felt at Sibsagar accompanied by cold and gloomy weather.\textsuperscript{30} On February 4, Nazira was rocked again.\textsuperscript{31} Gauhati was rocked on 23\textsuperscript{rd} October\textsuperscript{32} and again on 29\textsuperscript{th} October. On November 11 at 9-38 pm Gowhatty was rocked along with Calcutta, Darjeeling, Chittagong, Monghyr.

A series of earthquakes rocked the region in 1843. On April 6, 1843 Jeypur in upper Assam experienced consecutive violent shocks. Around the same hour Sibsagar was strongly rocked.\textsuperscript{33} Jeypur was rocked on the next day again. This time Dibrugarh and Sibsagar too were rocked.\textsuperscript{34} An interesting observation has been reported after the 6\textsuperscript{th} April earthquake from Sibsagar, Assam: a letter dated 7\textsuperscript{th} April from Sibsagar published in \textit{Friend of India} reads as follows:

\begin{quote}
...a very singular meteoric appearance was observed here a few evenings since. It occurred a little before 9 o'clock on the evening of the 4\textsuperscript{th}; a very brilliant light
\end{quote}

\textsuperscript{28} \textit{Ibid.}
\textsuperscript{29} \textit{Ibid.}
\textsuperscript{30} \textit{Ibid.}
\textsuperscript{31} \textit{Ibid.}
\textsuperscript{32} \textit{Ibid.}
\textsuperscript{33} \textit{Ibid.}
\textsuperscript{34} \textit{Ibid.}
suddenly illuminated the whole atmosphere, and on looking up a large cluster of falling stars was seen rapidly descending towards the East in an oblique direction. There disappeared in a few seconds, and about a minute afterwards a loud report was heard resembling that of a cannon, resulting doubtless from exploration of the luminous mass. The report was also heard at Jaypore. Last evening at half past 8, we had several very severe shocks of an Earthquake; the vibration lasted for about five minutes. Another slight shock was felt at a quarter-past 1 o’clock this morning.\textsuperscript{35}

A “strong and vertical” shocks was felt at Sibsagar on June 15, 1843.\textsuperscript{36} Jeypur next experienced one of the most violentful shocks one 16\textsuperscript{th} June 1843.\textsuperscript{37} On 17\textsuperscript{th} June 1843, consecutive 3\textsuperscript{rd} very sharp shock was felt at Sibsagar.\textsuperscript{38} On the night of September 2, 1843, Assam was rocked again.\textsuperscript{39} On 3\textsuperscript{rd} September 1843, there was another shock proceeding from the south with certain distinct manifestation just preceding the same.

After a very hot day clouds gathered at S, E, very close and sultry. Squell came on a little before sunset; vivid lighting all round the heavens; previous to squall breaking heard an extraordinary noise in the heavens overhead, like the falling of heavy rain on distant jungle, or like the rushing of wind through a funnel, with the noise was heard an occasional growl, like distant thunder. When the rain fell, this noise had continued for some time, thunder very high in the heaven, but the lighting one blaze all around; whilst at dinner a smart shock from the south.\textsuperscript{40}

\textsuperscript{36} Oldham, T., op. cit.
\textsuperscript{37} Ibid.
\textsuperscript{38} Ibid.
\textsuperscript{39} Ibid.
\textsuperscript{40} Baird, Smith, R. op. cit., pp. 845.
On November 14, there was a single shock in Gauhati. Gauhati was rocked again on December 18 very violently.

Subsequently, on August 6, 1845 Sylhet was rocked violently leading to destruction. Gauhati experienced the same quake, accompanied with a series of ten or twelve shocks during next 48 hours. The August 8 quake was so severe that it knocked down the new Church spire at Gauhati. The next week Gauhati felt at least 18 such shocks and incessant rumblings of the earth signifying commotions proceeding from the south. There was seven shock waves in Gauhati on August 22, 1845 during the mid-day which lasted half a minute accompanied by "rumbling sounds as of distant thunder". Between 3 and 5 pm another slight shock was felt in the same area, and these left people traumatic.

In 1846, there were about 15 shocks recorded in and around Mymensingh during 17th to 19th October and the other one in Assam on December 10th. In December 10, 1846 a sever shock jolted Assam which resulted in loose sandbanks falling along the Brahmaputra at several places. The Dubroo river got so agitated as if by a high wind. The Janrie, a small river in the Sibsagar district had risen by about six inches, the next morning while the water of Dakkho which rises near

41 Ibid.
42 Oldham, T., op. cit.
43 Ibid.
44 Ibid.
45 Ibid.
46 Ibid.
the other had sunk proportionately. On May 5, 1847, Calcutta was rocked by a sharp shock. The area was rocked again on 20 February, 1848 around 5 pm by another sharp shock. The series of shocks rocked Calcutta and Serampore again on November 30, 1848. In 1849 (January 22) Gauhati was rocked around 8.15 am. The tremors were felt mostly around Barpeta and caused by two successive shocks lasting about 1 to 1 ½ minutes. Next day at about 9 pm another strong shock came from south west to north west. It appears have come from the Himalayas and not from the Khasi hills. January 26 of the same year there were two shocks again. At 5 am Jogee was rocked while at 6 am Barpeta was rocked by two slight shocks. At Gauhati these were preceded for two or three seconds by a sound which continued for about the same time. On May 7, 1850 Calcutta experienced an earthquake accompanied by a hot blast of wind. Chittagong experienced a shake preceded by a dull thumping sound on January 8, 1851, which was also felt at Mymensingh, Daca and Calcutta. On February 9 and 17 of the same year Calcutta was rocked again. On October 15, 1865 a weak shock passed through Cherrapunji. On February 9, 1852 there was another shock rocking Calcutta and Serampore. On early May 1852 Darjeeling was rocked heavily. On August 9, the same year Dacca experienced oscillation lasting about 15 seconds.48

47 Ibid.
48 Ibid.
The next quakes were felt after a gap of few years in 1858 on August 24, which was felt at Darjeeling. A slight tremor was felt at Cherra and Chittagong. But similar shock came in 1861 in and around Calcutta on February 16, at about 7.30 am. Calcutta had a slight shock again on April 18, the same year. Dacca was rocked on January 5, 1864 by a severe jolt. The next earthquake came in December 15, 1865 felt at Calcutta. A series of shocks were felt from December 15 to 20, 1865 on the Chittagong region, during which earth surface were cracked at several places in the Roajan division. Chittagong was rocked again on January 6, 1866. Shocks were felt at Calcutta, Darjeeling and in the region on May 24, again the same year. On June 29, 1868 Cachar was jolted by minor shocks.\textsuperscript{49} The next day Sylhet felt severe convulsions which lasted for about half a minute. On June 31, Hazaribagh was rocked, the momentum seemed to have come from north or north east and preceded by a loud noise.\textsuperscript{50}

DEVASTATING EARTHQUAKES OF NORTH EAST INDIA DURING COLONIAL PERIOD

Cachar Earthquake (1869)

On 10\textsuperscript{th} January 1869 Cachar and Manipur Valley were rocked by a violent shock effecting Silchar and Imphal to a great extent. The main shock was followed by a number of 'aftershocks'\textsuperscript{*} till 14\textsuperscript{th} of January almost every day, and with a gap of three days again on 18\textsuperscript{th} January two shocks were felt. Major construction at Silchar and Imphal were

\textsuperscript{49} ibid.
\textsuperscript{50} ibid.
virtually destroyed and the entire Surma and Manipur Valley were
effected. T Oldham of Geological Survey of India, after thorough
scrutiny of the available records could roughly place the epicentre at
around 26°N latitude and 92°40'E longitude lying somewhere in
Jaintia Hills.51

On 17th April 1869 a sharp shock was felt at Shillong. "A large
number of shocks (about 100) reported from Shillong, Cachar,
Kamrup, Tejpur, Dubri, Nowgong, Khasi Hills, Sibsagar, Jorhat and
other areas of N E India during May 1874 to December 1877 by
Keatings."52 Of these, earthquake of 3rd September 1875 and those
of 26th January and 21st December 1876 deserve special mention
because of their violent nature.53 The shock of 5th September, 1875
at 6-30 pm as reported from Nowgong was accompanied by a loud
sound like the rumbling of distant thunder. Another shock on the
same day at about 7-15 pm attended Nowgong with the similar
rumbling noise like thunder.54 The shock of 26th September 1875 at
9-45 pm recorded at Darrang, Tezpur was also preceded by a
rumbling noise, which was slight but marked and only lasted a few
seconds. So was the case preceding another earthquake felt quite

* 'After Shocks' are those which follow a main shock and whose strength always
remain below the main shock and those are believed to have come from around
the same place as that of the main shock.
51 Oldham, T, 'the Cachar earthquake of 10th January 1869', R D Oldham (ed.),
(hereinafter Memoirs of T Oldham)
53 Col. Keatings, R H, Chief Commissioner, "XI-Record of the Occurrence of
Earthquakes in Assam during the years 1874, 1875, 1876", Journal of Asiatic
Society, No. 3, 1877, pp. 296-297 and 306-309.
54 Ibid., pp. 300-301.
violently at Darrang and Tezpur on 26th January 1876 at 3-20 am.

The shock of 13th November 1876 at 10-35 am felt at Darrang, Tezpur was accompanied by a rumbling noise as of artillery wagons going over stony ground, slight, but distinct. In the year 1877 there were a number of shocks. Out of these, so far as the severity is concerned, two sets of earthquakes deserve special mention which took place on two different dates. First set of two shocks of 11th May reported by four districts of Kamrup, Khasi Hills, Darrang and Nowgong, was declared to be the severest, since the great one in September 1875 (by the Deputy Commissioner of Darrang) and the other set being those of half a dozen distinct very severe shocks of 7th December, 1877 of which 2nd one was very strong and caused much damage. This year also there were a good number of shocks on 15th February, 3rd and 18th August, 11th December and 22nd December which were either preceded or accompanied by rumbling noise at time quite loud and long. Felt report of the earthquakes for the year were from almost all the districts of the Assam.

As reported the year 1878 was more or less free of any sever shock. But regarding the sound effect the year was quite significant. The shocks on 19th January, 3rd February, 5th February, 4th May, 5th July and 29th November, all of which were recorded at Tezpur,

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55 Ibid., pp. 304-309.
56 Col. Keatings, R H, Chief Commissioner, "III - Record of Occurrence of Earthquake in Assam during 1877", *Journal of Asiatic Society*, No. 1, 1878, pp. 4-5 & 8-9, 11.
57 Ibid., pp. 4
58 Ibid.
Darrang were also recorded to be preceded by rumbling noises, at times unusually loud and prolonged. The shock of 3rd February was recorded to be 'very loud' and 'distinct'.

Rumbling noise phenomena appears to be something very peculiar to the district of Darrang only, at least for the year 1878, as no other station has recorded even a single shock preceded by that rumbling noise that year. It is very interesting to note that in the year 1877, also rumbling sound preceding the earthquakes are recorded from Darrang, Tezpur only with the exception of Nowgong - twice reporting the noise along with Darrang, Tezpur. From 1874 onwards it could be seen that though it is not only Darrang who only reported rumbling sound, but it is almost but sure that Darrang, Tezpur has recorded the noise effect (preceding an earthquake) most. The observation very particular to Darrang, however, defy any logical explanation as yet.

The years 1879 and 1880 though witnessed quite a number of earthquakes in N E India but those were mostly mild. In 1879 on January 3, there was a smart shock as recorded at Lakhimpur accompanied and preceded by the usual rumbling sound but having a shorter tone than ordinary. Some damage was also ensured by this shock which took place around 3 am, i.e., early in the morning. There were no more shocks in that year severe than that of 3rd January,

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60 Ibid., pp. 35, 38, 41.
1879. However, Darrang recorded two slight shocks on 16th and 27th of December that year which were preceded by a prolonged rumbling noise. There were three recorded shocks in the year 1880. First one in May 2, at about 2-50 am, severely felt at Nowgong, the second one was a double shock of considerable violence—first a slight shock followed by a severe one, took place on 30th June at 4 am, 1880. This was accompanied and followed by a loud rumbling sound, recorded at Garo Hills, Goalpara and Kamrup. The same shock at around 3-55 am to 4-00 am also shook Naga Hills, Mangaldai subdivision, Golaghat subdivision, Jorhat subdivision, Karimganj subdivision and Nowgong. Vibration was sufficient to throw down decanters and such like articles at Naga Hills, to develop four cracks in the treasury building at Golaghat, to shook the wooden post of the SDO's bungalow alarmingly. The third severe seismic event of the year was there in the region on 30th September at 7-50 pm affecting mostly Darrang. Severe shock followed about a minute later by a second shock not quite so severe. Accompaniment of sound along many a shocks were a regular factor of the year. While writing about the great shock of 1897 the then officiating Commissioner of Assam Valley was recapitulating his experience of earthquake during 1870s and 1880s in the region in this way:

The present is the third seismic disturbance of some severity I have experienced in the province. In 1876, an earth tremor occurred, which rocked the arches of

*List of Earthquakes recorded in Assam during the years 1879 and 1880 by the Government of Assam*, *Journal of Asiatic Society*, no. 1, 1881, pp. 61-67.
the brick buildings in North Lakhimpur, and which for some minutes made standing upright a difficulty, and again, in 1885 a very similar earthquake happened when I was stationed in Tura, Garo Hills, which completely levelled the stone built treasury and police quarter guard.\(^{62}\)

In 1882 a shock was felt at Silchar and in 1885 along with the major shock there were about 10 after shocks on the same day of July 14 felt around Dacca. On July 24, 1885 a shock was felt at Rongpur and on June 17-18, 1891 two shocks were felt at Sirajganj, Bangladesh.\(^{63}\)

In between, in 1883, De Rossi of Italy and Forel of Switzerland who were working on the effects of earthquakes more less independently, joined hands and the famous Rossi-Forel scale of measuring earthquake intensities was set up in 1884.\(^{64}\) An enormous range of intensity was lumped together at its highest mark X in the Rossi-Forel scale. This limitation of the scale was soon rectified and by 1902 Mercali put forward the improved version of it. This Mercali scale was also further modified and by 1931, it became the most accepted scale under the title 'Modified Mercali Intensity Scale'.\(^{65}\) The scale is detailed below.


\(^{63}\) Gupta, H K, et al., op. cit.

\(^{64}\) Richter, P F, op. cit., p. 135.

\(^{65}\) Ibid., p. 136.
Modified Mercalli Intensity Scale of 1931  
(1956 Version Abridged and Rewritten)

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<thead>
<tr>
<th>Intensity</th>
<th>Description</th>
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<tr>
<td>I</td>
<td>Not felt. Marginal and long-period effects of large earthquakes.</td>
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<tr>
<td>II</td>
<td>Felt by persons at rest, on upper floors, or favourably placed.</td>
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<tr>
<td>VIII</td>
<td>Steering of motor are affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from...</td>
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trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.

IX General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. (General damage to foundations – CFR). Frame structures, if not bolted, shifted off foundations. Frames cracked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alleviated areas sand and mud ejected, earthquake fountains, sand craters.

X Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.

XI Rails bent greatly. Underground pipelines completely out of service.

XII Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

Note: CFR, Charles F Richter additions to the 1931 scale. Masonry A, good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete etc., designed to resist lateral forces; masonry B, good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces; masonry C, ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces; masonry D, weak materials, such as adobe, poor mortar, low standards of workmanship, weak horizontally.

THE EARTHQUAKE THAT SHOOK THE WORLD

The Great Shillong Earthquake (1897)

After Rossi-Forel Scale and Milne seismograph came into being, North East India was rocked by one of the greatest known earthquakes (Annexure – II) in historical time on 12th of June 1897 having its
epicentre on Shillong plateau. The earthquake goes by the name of Great Shillong Earthquake. The total area over which the shock was felt was 1750000 sq. miles and the area over which serious damage was caused was 160,000 sq. miles. These figures of both felt and affected are so far the largest by any Indian earthquake. The then Shillong was virtually ruined and all the adjoining districts even up to Nowgong of the North Eastern Region were very severely affected. As was recorded by R D Oldham while surveying in the epicentral tract that there was a distinct evidence of movement of the ground over 35 feet across the Chedrang fault in the Shillong plateau which mostly responsible for causing the earthquake by releasing the accumulated strain energy in the form of seismic waves. Across another fault about 10 miles due south to that of Chedrang called Samin fault, there also evidence of ground movement was available though of lesser degree. The epicentral location for this earthquake as identified by Milne was 25.9°N latitude and 91.8°E longitude. The effect of the earthquake when re-evaluated, Richter puts it this way, "The whole group of effects in the meizoseismal* are of 1897 furnished the principal model for the highest grade XII, of the Modified

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68 *ibid.*, p. 147.

* the area within the isoseismal lines (the lines connecting localities where equal intensity is observed) of higher intensity.
Mercalli Intensity Scale". Professor Omori, the Japanese expert who visited Shillong following the earthquake, expressed the opinion that the earthquake was due to a fault in the earth's crust about 20 miles below the surface. After shocks of this great earthquake were also very large in number.

In Shillong itself it was estimated that there were two hundred shocks a day for a few days after the 12th of June, these had gradually diminished to twenty or thirty shock a day by the middle of July. Then they became fewer, but for at least two years after the earthquake we were accustomed to a daily shock. Occasionally these were of alarming intensity, but familiarity led to their being treated with contempt. Shocks had become rare when I left Assam at the end of April, 1902, but I may safely estimate that we acquired an experience of about four thousand quake.

As per R D Oldham's record, the number of after shocks till December 1902 was 5168. This figure was arrived at after thorough scrutiny of both observers' as well as instrumental records.

After 1897 till 1950 fifteen major earthquake took place in North Eastern India i.e., within 22°-30° N latitude and 88°-97°E longitude. It may be worth mentioning here that in 1935 Charles F Richter introduced the concept of magnitude in measuring the size of an earthquake. Since, so long intensity, which was a measure of net effect at a particular place mostly dependent on the distance from the place of origin of the shock was creating a confusion about the actual

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69 Richter, C F, op. cit., p. 54.
71 :id., p. 235.
strength or size of an earthquake, Richter through his concept of magnitude wanted to deduce a figure which would be proportional to the net release of energy by an earthquake and so would be independent of feelings at a particular location rather from all the position whoever would feel or record it through instrument would deduce the same figure which would be known as magnitude. Since, this was developed by Richter this magnitude went by his name — Richter magnitude. This magnitude scale afterwards has been classified in the distinct manner.

An earthquake is called GREAT when magnitude is greater than or equal to 8 in the Richter scale.

An earthquake is called MAJOR when magnitude is greater than or equal to 7 or less than or equal to 7.9 in Richter scale.

An earthquake is called LARGE (destructive) when magnitude is greater than or equal to 6 or less than or equal to 6.9 in Richter scale.

An earthquake is called MODERATE (damaging) when magnitude is greater than or equal to 5 or less than or equal to 5.9 in Richter scale.

An earthquake is called MINOR (slight damage) when magnitude is greater than or equal to 4 or less than or equal to 4.9 in Richter scale.

An earthquake is called GENERALLY FELT when magnitude is greater than or equal to 3 or less than or equal to 3.9 in Richter scale.

An earthquake is called POTENTIALLY PERCEPTIBLE when magnitude is greater than or equal to 2 or less than or equal to 2.9 in Richter scale.

An earthquake is called MICRO EARTHQUAKE when magnitude is less than 2 in Richter scale.
After this scale was developed, from the old records of North Eastern Region all the earthquakes were re-designated in terms of magnitude. Now from the published list of earthquakes, it is seen that North Eastern India has witnessed fifteen shocks during 1897 to 1950 whose magnitudes were equal to or above 7\textsuperscript{75} in the Richter scale. Of these, a good number to be specific though is in Burmese (present Myanmar) territory but they all are a part of the same geological formation of the Indo-Burmese border zone and hence, constituted the part of North Eastern Region earthquake because of common casualty, i.e., being a part of same tectonic regime.

**SRIMANGAL EARTHQUAKE OF 1918**

Of all those fifteen earthquakes excluding the two great shocks of 1897 and 1950 - two of 1918 and 1930 were also very fatal to the region. The earthquake of 8\textsuperscript{th} July 1918 popularly known as Srimangal Earthquake had a shattering effect in the area surrounding Srimangal Pargana in the erstwhile district of Sylhet. The tea gardens in the epicentral area were the worst sufferer. The coolie lines, the managers' bungalow, the leaf house of a number of tea gardens were levelled to the ground.\textsuperscript{76} In the Richter scale the magnitude of the earthquake was later calculated to be 7.6,\textsuperscript{77} i.e., a major one. The earthquake was possibly preceded by three fore-shocks before the

\textsuperscript{75} Gupta, H K, et al., *op. cit.*

\textsuperscript{76} Stuart, Murray, 'the Srimangal Earthquake of 8\textsuperscript{th} July, 1918', *Memoirs of the Geological Survey of India*, vol. 46, Calcutta, p. 7.

\textsuperscript{77} Gupta, H K et al., *op. cit.*, p. 356.
main one on 8\textsuperscript{th} July. A number of after shocks were reported, some of which were strong enough to be recorded on the seismograph at the Alipur observatory, Calcutta. Sixteen prominent after shocks are available in the record.\textsuperscript{78} The violent Srimangal earthquake was felt over 800,000 sq. miles.

**DHUBRI EARTHQUAKE OF 1930**

The Dhubri earthquake of 3\textsuperscript{rd} July 1930 was another violent earthquake that visited the region. The intensity of the earthquake in the epicentral area was equivalent to the mark IX of the Rossi-Forel scale and Dhubri town, the headquarters of the Goalpara district being within the epicentral area was heavily effected. The main shock appeared to have travelled at the surface as a distinct wave or succession of waves. The main shock of 3\textsuperscript{rd} July was followed by great number of after shocks till June, 1933. The total number of after shock as per Geological Survey of India records was 397,\textsuperscript{79} whereas *Englishman* in its edition of 18\textsuperscript{th} July, 1932 reported that 'The total number of shocks, felt here (at Dhubri) since July 1930, was 511' to which Geological Survey of India did not have any objection.

The aftershocks were so numerous that it was really a problem to record them. During the 1\textsuperscript{st} 21\frac{1}{2} hours succeeding the main shock on 3\textsuperscript{rd} July a total of 54 shocks were recorded. Almost all of these

\textsuperscript{78} Stuart Murray, *op. cit.*, p. 54.

were experienced at Dhubri, a number of them at Gauhati, whilst one recorded at about 5-49 am was felt at much greater distance from the Dhubri epicentre.\footnote{Ibid., pp. 79, 83.}

On the 4\textsuperscript{th} and 5\textsuperscript{th} of July, 1930, 37 and 34 shocks respectively were recorded. Again a large number of these appeared to have originated near the epicentre of main earthquake, though others not registered at Dhubri, these suggest on origin higher up the Brahmaputra Valley in the vicinity of Gauhati.\footnote{Ibid., p. 80.}

The Dhubri shock was of magnitudes 7.1 in Richter scale.\footnote{Chandra, U, 'Seismotectonics of Himalaya', \textit{Current Science (Special Issue)}, vol. 62, no. 1 & 2, 25\textsuperscript{th} January, 1992, p. 46.} Prior to 1930 Dhubri earthquake, south-west of Assam was rocked by a major earthquake on 9\textsuperscript{th} September 1923 whose epicentre was at 25.2\degree N latitude and 91\degree E longitude. It caused some damage to structures near epicentral region over West of Assam and Northern part of East Bengal.\footnote{Tandon, A N, \textit{op. cit.}, p. 154.}

After Dhubri earthquake of 1930, North East India was again rocked by another great earthquake on 15\textsuperscript{th} of August 1950. And in between these two, the North Eastern Region had to face six major earthquakes in the years 1931, 1932, 1938, 1943, 1946, 1947 whose magnitudes were greater than 7 in the Richter scale. Of these, the shock of 1932 caused some damage to the epicentral area in Nagaland and slight damage in the eastern part of North East Assam.\footnote{Gupta, H K et al., \textit{op. cit.}, pp. 357-359.} The shock of 1943 had destructive role over North East
Assam and minor damage over Northern parts of Assam.\textsuperscript{85} When 1947 shock, whose epicentre was about 100 miles northwest of Dibrugarh had damaged buildings in part of North East Assam,\textsuperscript{86} the other shocks being located within the hilly terrain of Burmese territory no record of loss of lives or destruction of property could be traced.

DEVASTATING EARTHQUAKE DURING POST COLONIAL PERIOD

THE GREAT ASSAM EARTHQUAKE (1950)

The first great earthquakes of independent India had its focus in its most earthquake trodden north eastern part. Epicentre of this great earthquake of 15\textsuperscript{th} August 1950 was in the Sino-Indian border at the boundary of Arunachal Pradesh little beyond the place where Lohit river enters India through extreme North Eastern corner had effected mostly the erstwhile NEFA and upper Assam. The earthquake had disastrous impact on the lives and properties of the people as well as on the ecology and environment of the North Eastern Region.

The earthquake was preceded by a number of fore shocks and was followed by a good number of after shocks. There were also five well recorded foreshocks beginning with that of 17\textsuperscript{th} November 1949 till 12\textsuperscript{th} August 1950.\textsuperscript{87} The recorded number of after shocks till April

\textsuperscript{85} Ibid., pp. 359, 364.
\textsuperscript{86} Ibid.
\textsuperscript{87} Pramanik, S K, 'The Assam Earthquake'. M B Ramachandra Rao (compiled), \textit{Compilation of Papers on the Assam Earthquake of 15\textsuperscript{th} August 1950}, Central Board of Geophysics, Govt. of India Publication No. 1, Calcutta, 1953, p. 30.
17, 1951 for which epicentres were determined at Poona was 27. Whereas on establishment of seismographs at Tezpur, Toklai and Shillong by the end of October and early November, the number of shocks recorded at Shillong and Tezpur during November 1950 to March 15th 1951 were 157 and 212 respectively. From the records it could be seen that at Shillong activity decreased after January whereas in Tezpur the same being maintained even after March 15, 1951. The area over which the earthquake was felt was 11,30,000 sq. miles and it had caused severe damage over an area of 75,000 sq. miles. At Dibrugarh, the place very much within epicentral zone had felt 250 after shocks up to the end of August 1950. As a matter of fact, at Dibrugarh and other affected areas ground was hardly at rest during the night of 15th August 1950. The magnitude of this great earthquake as per the revised magnitude list is 8.7 in the Richter scale.

In the last decade of the study period after the great earthquake of 15th August, 1950 there occurred a large number of shocks within the tectonic framework of this region. Since 1st seismograph was installed in the region after the great earthquake of 1950, the number of earthquakes recorded in between 1950 and 1960 were much above during any other decade prior to that. The number of earthquakes

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88 Ibid., pp. 30-31.  
89 Tandon, A N, op. cit., p. 150.  
90 Ibid., pp. 150-151.  
91 Ibid., p. 150.  
92 Richter, C F, op. cit., p. 713.
having magnitude 6 and above in the Richter scale comes to about 102, which have occurred in the region after that great one of the 15th August, 1950 inclusive of the year 1960. In which we have another great earthquake of 18th November, 1951, which took place at 9 hours, 35 minutes and 6 seconds and whose epicentre was at 31.1°N and 91.4°E. Out of those 102 shocks of magnitude 6 and above, seven were having magnitude 7 and above in the Richter scale. In an earthquakes of 17th August, 1952 within the vicinity of the region, 65 people were killed, 157 injured whose magnitude was estimated to be 7.5 in the Richter scale. The list of all earthquake of this decade in region are there in Annexure – I. This decade though primarily a decade of after shocks, it has certain independent major shocks also. Thus, the huge list of earthquakes of different magnitude from the lowest to the highest could very easily place the region as one of the most seismic prone zones of the world.

**CASUALTY**

During the same period, i.e., 1880s a significant development was taking place in the field of Seismology. John Milne a British Engineer had been trying hard to develop seismograph in Japan and the first effective seismograph was developed there by Gray, Milne and Ewing in 1880. The fabrication of the first compact seismograph

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was done by Milne in 1892\textsuperscript{95} and the new era of seismology began. Thereafter with the formation of the Committee on Seismology by British Association for Advancement of Science in 1896 enabled John Milne to establish seismograph station with world wide distribution and it was these instruments – spreading over a wider area on the globe – which could successfully record the great Shillong earthquake of 1897.\textsuperscript{96} This instrumental recording of earthquakes immediately facilitated the location of the place of origin of the seismic events more precisely. Assuming origin of earthquake is from a point source inside the earth, the point just above the source on the surface of the earth is called the epicentre and the actual position inside the earth from where the seismic waves actually disseminates is called hypocentre. Following the identification of the place of origin of earthquakes on the surface of the earth in the form of latitude and longitude, plotting of the epicentral locations on the maps of the globe was started by the early part of the twentieth century.

In Italy under the leadership of Robert Mallet the knowledge of earthquake was being organised into a science of seismology and in 1846 he presented his first paper on the dynamics of earthquake before the Irish Academy. Contribution of Robert Mallet in

\textsuperscript{95} Agarwal, P N, \textit{Engineering Seismology}, p. 46.
systematisation of the knowledge of earthquake in that early stage was simply unparallel.\textsuperscript{97}

Since Ahom period to 1960 most of the major shocks and a good number of moderate and large shocks could be recorded as well as for which epicentre could be determined they could safely be plotted in a map of North Eastern India. Number of shocks, thus recorded between 1897 and 1960 are found to be 475\textsuperscript{98}. All these shocks when plotted in the map of the North Eastern Region, they reveal a pattern, vis-à-vis the geographical set up of the region. Immediately, simply from the frequency of earthquakes the region could be further subdivided into four seismic sub-zones – Eastern Himalayan boundary, Indo-Burmese border zone with Arakanyuma Peguyama Hill range, Shillong plateau area and rest of the valley areas of Assam comprising both Brahmaputra and Barak valley areas. Of these, seismically Indo-Burmese border zone seems to be very active with Himalayan border in the next position, whereas upper Assam valley appears to be almost aseismic when Shillong plateau though a producer of the Great Shillong Earthquake, the frequency of shock there appears to be moderate. The shocks in the Ahom period though could not be precisely plotted in the map but their suggested occurrence around Brahmaputra Valley do not at all disturb the seismic distribution pattern of the region, deciphered out of the later records, rather strengthen it.

\textsuperscript{97} Richter, C F, \textit{op. cit.}, p. 30.
\textsuperscript{98} Gupta, H K, \textit{et al.}, \textit{op. cit.}, pp. 356-360.
The plotting of epicentre on the map started quite early and by 1930 the identification of the general distribution of seismic belts on the globe was more or less complete. Subsequently with the accumulation of more earthquake data gradually Alpide belt could be traced up to Burma well beyond the Himalayan range. As it has been put,

The Alpide belt can be traced westward as a series of arcs with generally Southward front, in Burma, the Himalaya, Baluchistan, Iran, Anatolia and the eastern Mediterranean (Crete). Recent authorities (Stille and others) continue the tectonic zone with sharp bends, reminiscent of the zone of the East Indies, around the Adriatic into the Alps and back by way of the Appennines; here we have the Italian arc of Chapter 4. The continuation is then through Sicily and the North Coast of Africa, and into the Atlantic as far as the Azores where the Atlantic belt is reached. The Alpide belt has a northern front, characterised by minor to moderate seismicity which involves the Pyrenees, the Carpathians, the Caucasus, the Crimea, and the Kopet-Dogh.99

Thus, with the development of knowledge on the seismic behaviour of the earth, North East India could very justifiably be identified as a part of the Alpide-Himalayan seismic belt.

When the seismic geography was in the offing, another very interesting theory of wandering continents was put forward by Alfred Wegener in 1912100 known as the Theory of Continental Drift. According to this theory, all the continents were once together and was named as Pangaea. That single whole over geologic periods broke into a number of parts and drifted apart forming the present set

up of the continents and they are still in motion. This continental drift
theory over the years gave birth to the idea of Plate-Tectonics – the
most important contemporary theory for explaining the seismic
behaviour of the globe.\textsuperscript{101} And this theory could so far explain the
seismic pattern of the North Eastern Region in a least objectionable
way though certain complex features are yet to be explained.\textsuperscript{102}
According to this theory, North Eastern India is sandwiched between
two sets plate junctions. In the north, junction is in between Indian
and Eurasian Plate whereas in the East and South-east the junction is
known as Indo-Burmese plate junction.\textsuperscript{103} From the Shillong plateau
to Mishimi Hills, it is the exposed Precambrian rock family there after
going below Brahmaputra alluvium till this reaches the syntaxis, the
extreme corner of N E India. It is believed to be a part of the
Peninsular India which has been drifted apart horizontally by about
250 km from the Rajmahal Hills of Jharkhand. In Shillong Plateau and
Mikir Hills the basement rock is uplifted and is visible, whereas in
upper Assam area beyond Mikir Hills the basement rock has gone
down and is overlaid by very thick alluvium of over a few kilometres.
This act of horizontal movement – as has been put – has taken place
along the well known Dawki fault.\textsuperscript{104} So it is seen that the entire North

\textsuperscript{102} Rajendra, K, Talwani, P and Gupta, H K, ‘State of Stress in the Indian
Subcontinent : A Review’, \textit{Current Science (Special Issue)}, vol. 62, no. 1 & 2, 25
\textsuperscript{103} Mukhapadhyay, M, ‘On Earthquake Focal Mechanism Study for the Burmese
Arc’, \textit{Current Science (Special Issue)}, vol. 62, No. 1&2, 25 January, 1992, pp. 72-
84.
\textsuperscript{104} Evans, P, \textit{op. cit.}, pp. 80-96.
Eastern Region of India is almost encompassed by the very active plate boundaries along which the relative displacement of plates are always on, resulting in slips and sudden slips very often, and in the process thereby releasing huge amount of accumulated strain energy in the form of seismic waves – popularly known as earthquakes. The Surma Valley to the south of Dawki fault is the continuation of the Bengal plane up to the Manipur Hills to the east. It is also said that, the eastern Himalayan Hill range to the Naga Hills in the east and then the formation of Arakanyuma and Peguyama Hill range along the Indo-Burmese border going deep down the South are nothing but the results of the collision of plates. Shillong Plateau region, which exhibits a considerable seismic activity and has risen to the present height through long geologic eras, happens to display a controversial situation about its own origin and tectonic history. Epicentral plottings on the map of the region matches quite well to the on going scheme of plate tectonics. Two sets of plate junctions comprising almost the international boundary of the region are the crack zones along which most of the earthquakes are located.

Further, when the list of data for the 19th and 20th century till the study period are looked into, it appears that there is a characteristic pattern so far as the frequency of earthquake shocks are concerned. It seems after a gap of a few years there has always been a swarm of earthquake in the region, ultimately culminating to a great or at least a
major seismic event, specific to certain areas of the region. The swarms so far identified are described below:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Date of the main shock</th>
<th>Beginning of the earthquake swarm activity</th>
<th>Standard Arch between</th>
<th>Magnitude of the main shock</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>June 12, 1897</td>
<td>May 2, 1874</td>
<td>24°-28°N 89°-95°E</td>
<td>8.7</td>
</tr>
<tr>
<td>2.</td>
<td>Sept 12, 1946</td>
<td>Dec 5, 1934</td>
<td>21°-26°N 98°-98°E</td>
<td>7.75</td>
</tr>
<tr>
<td>3.</td>
<td>July 29, 1947</td>
<td>Feb 11, 1936</td>
<td>24°-29.5°N 88.5°-94.5°E</td>
<td>7.75</td>
</tr>
<tr>
<td>4.</td>
<td>Aug 15, 1950</td>
<td>Jan 30, 1924</td>
<td>22°-33°N 93°-100°E</td>
<td>7.75</td>
</tr>
<tr>
<td>5.</td>
<td>Nov 18, 1951</td>
<td>Dec 14, 1934</td>
<td>28°-33°N 85°-93°E</td>
<td>8.0</td>
</tr>
</tbody>
</table>

As is seen, rumbling noise of a very prominent degree happen to be another very common feature of almost all the big earthquakes those took place in the region.

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