Symposium on the Assam Earthquake of August 15, 1950

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Under the auspices of the Central Board of Geophysics a symposium on the above subject was held at the Geological Survey of India on 24 April 1951. The symposium was inaugurated by the Hon'ble Sri Prakasa, Minister for Natural Resources & Scientific Research, Government of India.

In a brief address opening the symposium, the Hon'ble Sri Prakasa said that as Governor of Assam during the 15 months' tenure of his office, he had developed not only a liking for that State, but that he had also taken great fascination for the beautiful Abor Hills. Unfortunately those hills particularly had suffered more intensely than any other place during the calamity that befell on August 15, 1950 and this made him especially sad. He felt that while the scientific collection of data and formulation of theories were useful and important, the human aspects of these tragic happenings should also be studied.

A. N. Khosla, Chairman of the Central Board of Geophysics, in his presidential address, briefly outlined the function of the Central Board of Geophysics and stated that in addition to its normal business meetings, the Board held technical meetings at which papers on geophysical subjects were presented and discussed. The Board had realised the desirability of bringing together all factual information concerning natural catastrophic phenomena such as earthquakes, cyclones, storm tides, floods, droughts, etc., for promoting a co-ordinated objective study. The symposium on the Assam Earthquake of August 15, 1950, had been convened inviting papers from geologists, geophysicists, engineers and others representing various departments of Government and private institutions who had collected factual information on the various aspects of this earthquake.

He also stressed that when compared with Japan, USA, and some other countries, seismological work in India had not so far received adequate attention. India had altogether only 7 seismological observatories, whereas Japan had 25 and USA over 49. More particularly, it was deplorable that in India there was total lack of studies of the strong motions produced by earthquakes in the belt which runs along the Himalayas extending from the Punjab in the west to Assam in the east. Earthquakes, large and small in that belt, were fairly frequent and it so happened that that very region had a great potential for river valley development. A large number of high dams were to be constructed and the importance of seismological studies had become in India a matter of great practical importance and urgency. With the setting up of proposed seismological observatories at Shillong and establishment of other recording stations, there should soon be collection of important data and their interpretation to gain knowledge concerning the characteristics of the earthquake waves.

Altogether 11 papers were presented at the Symposium covering various aspects. The geophysical aspects, putting forward a discussion of seismological data and their bearing on the geological problems were dealt with in the papers by S. K. Banerji, S. K. Pramanik and S. M. Mukherjee, B.L. Gulatee, and S. Ray.

The data collected by direct geological observations during field studies, together with a discussion on the nature of the tectonic movements, and the changes brought about as a result of the earthquake, were dealt with by V. H. Boileau, M.C. Poddar, S. E. Churchfield and L. P. Mathur.

The engineering aspects, *i.e.*, specially the data pertaining to the effects of the regime of the rivers, damage to roads, bridges, buildings and property were detailed in the

papers presented by G. R. Garg, C. H. T. Seignior and S. P. Choudhury.

It is proposed to publish shortly all these papers as a special publication of the Central Board of Geophysics. A gist of the paper presented at the meeting is given below—

1. Dr. S. K. BANERJI, Retd. Director General of Observatories, India, in a paper entitled *The origin and the nature of the disturbances produced by the Assam Earthquake of August 15, 1950 and its after shocks* discussed the magnitude, the operative causes, and the effect of the geological features on the transmission of seismic waves. He estimated the energy of the earthquake was of the order of 10^{27} ergs, assuming the Magnitude at 8·6. According to his analysis, the depth of the earthquake was of the order of 15 km, and he considered that the energy must have been produced as a result of a number of rocks or a single solid rock occupying a large volume subjected to gradually increasing strain, reaching the yielding point and finally cracking.

He figured that in order to produce an energy of the order of 10^{25} ergs by breaking a large number of blocks of rock of the dimension of 2km × 1km × 100m would collectively occupy a volume which would almost fill the earth—which clearly could not be a reasonable assumption. He then proceeded to a consideration of the state of materials at depths between 15 and 40 km. After discussing the data obtained in experimental observations by Karman, Adams, Griggs and others, he concluded that in the Assam Earthquake a block of rock extending 200 km × 100 km, 10 km thick must have been subjected to breaking strain on the surface, that would cover almost the same area as had been outlined under isoseismal X, covering the Khasia Hills and the great arc in the northeast corner of Assam. When such a large volume was concerned, and the depth of focus was 20 km or 25 km, it was more precise to state that the upper surface of the block which reached the breaking strain was at that depth. If geologically the region was homogeneous, the isoseismals could have been a series of concentric circles. Actually, however, they were found to be elongated along the valley, indicating that the trend of the mountains which made a corner in the region at an angle of about 60°, exercised a profound influence on the propagation of seismic surface waves. Banerji also held tentatively a view that the Gangetic alluvium in this region behaved just as a whispering gallery, and that the thickness of alluvium was probably comparable to the wave length of seismic waves of short periods of 2 to 3 seconds, that is, the depth probably was of the order of about 20,000 ft.

2. Shri B. L. GULATEE, Director, Geodetic & Training Circle, Survey of India, presented the *Geodetic & Geophysical aspects of the Earthquakes in Assam.* He drew attention to the planimetric and vertical displacements caused by the earthquake. There had been still a lack of undisputed data regarding the displacements from observations at triangulation stations. As regards the epicentre of the earthquake of August 15, 1950, it was located beyond the Indian frontiers and there was hardly any triangulation inside isoseismal zone X. Two of the new principal series executed recently were in the zone affected by this earthquake, and these stations had been rendered unreliable by the shaking to which the ground was subjected to. The earthquake had thus undone the precise link that had been established between the primary framework of Assam and Burma. However, the Survey of India had on hand proposals for revisionary triangulation. He then discussed the association of gravity anomalies in the earthquake zones of India. He considered that generalisation was difficult, and that the gravity anomaly in each region had to be considered on its own merits for an explanation. The line of pronounced negative anomalies extending from the seas to the southwest of Sumatra and Java to Mollucca Passage was a tectonic line of structural instability, and characterised a region in the first phase of mountain formation. It was reasonable to consider it as an extension of the Himalayan line of negative anomalies, joined by the pronounced negative anomaly in the centre of Burma. That, however, would not necessarily mean that every region of underload focussed by gravity or geodial data was ripe for an earthquake. A judicious selection of the type of gravity

anomaly was very essential and the assumptions and limitations should be clearly realised. The line of crustal down-warping, as derived from F anomalies, was indicative of a region where shattering earthquakes could occur. Such mixed anomalies were open to grave objections, as they were based only on *ad hoc* assumptions. They were useful when applied to limited regions, but could not be applied to India as a whole.

Gulatee then referred to computations made by the Burma Oil Co. over 6000 gravity stations in Bengal, Assam and Burma. The G anomalies obtained by geological corrections, showed a close correlation to main tectonic lines. The Upper Assam Valley was a region of strongly marked negative anomalies, as also the line of uplift in hills separating Assam and Bengal from Burma. The deltas of Bengal and Irrawaddy and the volcanic line of Burma showed positive anomalies. A study of the epicentre of earthquakes in Assam reveals that they are distributed at random irrespective of the sign of the gravity anomalies. The epicentral tract of 1897 earthquake was in the region of positive gravity anomalies, while the 1950 epicentre occurred in a markedly negative region. The greatest positive and negative anomalies in the whole of India, were centred in Assam, especially in North Lakshimpur where considerable damages had occurred. That locality was known to have the largest negative isostatic anomaly, amounting to —120 mgals. At Dibrugarh also the gravity anomaly noted was very large. Further gravimetric data were necessary to study the problem in entirety.

3. Dr. S. K. PRAMANIK and Dr. S. M. MUKHERJEE of the India Meteorological Department, presented comprehensive factual data concerning this earthquake. The exact time of occurrence was noted as 19 hr 39·5 min IST (14 hr 9·5 min GMT) of August 15, 1950. It was felt over an area of 1·75 million square miles. The location of epicentre according to computations of the different Seismological Stations of the world, varied slightly but the available data warranted accepting the position as 28° 6′ N and 96° E. The nature of the shock was stated to be of tectonic origin, and the depth estimated some 14 kilometres below the surface. The direction of movement as experienced by different observers has been noted. The duration of the main shock was said to be about 4 minutes.

The nature of the foreshock and after shocks was described and the details furnished in a tabular form. One interesting fact stated was that there was a fairly well recorded shock on August 12, 1950,—three days preceding the catastrophic earthquake.

The Magnitude of the earthquake estimated both at Pasadena and Strasbourg was 8·6; and it was pointed out that in the period between 1904 and 1950 in India and neighbourhood, there were 50 earthquakes, the magnitude of which was 7 and over.

The Assam earthquake of 1950 was also compared with others of the different parts of the world, of magnitude 8 and above, and it was one of the greatest five which have been recorded in historic times. The energy of the shock has been estimated at 3×10^{27} ergs, *i.e.*, several million times the energy released in an explosion of an atom bomb.

The acceleration produced by this earthquake was discussed in detail. The only instrumental determination that was possible was from Chatra which was located in isoseismal zone V, where an acceleration of 12 cm sec^{-2} had been recorded. From the destruction and damage caused, the acceleration at the epicentral region was estimated to have been of the order of ·5g. The acceleration of the earthquake in relation to the construction for various engineering projects in India was considered and the authors calculated that as a very rough estimate, the acceleration of ·2g for rock foundations, ·4g for alluvium, and of the order of 1g for tops of very tall structures would have to be allowed.

4. Prof. S. RAY of the Calcutta Presidency College, dealt with a study he had made of the reports published in various newspapers and other sources. The isoseismals for this earthquake were drawn by him from such material. He preferred to call the isoseismals drawn by him as "iso-acceleration" or "iso-diastropic" lines. The epicentral tract appeared as a belt 50 to 100 miles long, and 30 to 60 miles in width. The ellipsoidal disposition of the isoseismals was

noteworthy, and was probably caused by some displacement along an elongated axis. Also the unequal spacing of the lines indicated that the movement was inclined to the horizon. Ray's conclusion was that the earthquake originated probably by the displacement along a major fault surface lying across the Assam syntaxial belt, striking Northeast to Southwest for about 100 miles or so, and hading at least in its eastern portion, to the northwest. The fault was probably rather deep seated.

5. Shri M. C. PODDAR, Geologist, Geological Survey of India, presented a comprehensive note covering the investigation conducted by the Geological Survey of India field parties which were deputed to examine the affected area after the earthquake. Observations had also been made during reconnaissance flights over the most seriously affected Abor and Mishmi Hills ranges. From the field data collected, a map showing isoseismal lines was presented, as also a detailed account of the isoseismal zones X to IX. The location of the epicentre was given as 28° 40′ N 96°E in the Dibang Valley. As regards the origin of the earthquake, Poddar ruled out the possibility of volcanic origin, and ascribed a tectonic origin.

Reports collected concerning the experience of the people on the sound and vibrations caused by the earthquake were also dealt with in detail by Poddar. It was said that some people at the foot of the Mishmi Hills felt the primary shock as lasting for 15 minutes, and the movement as gyratory or clockwise.

In the latter part of his paper, Poddar dealt with the land slides and their distribution, as also the effects produced by the earthquake on the rivers in that region.

As regards casualties, a total number of 1526 deaths had been reported, out of which 952 were from Mishmi and Abor Hills. Of the remaining 574, over 80 per cent of the deaths were caused by sudden floods in the Subansiri river. Poddar stated that fortunately, the severely affected areas were generally sparsely populated, and that the earthquake itself occurred just after the nightfall when the most of the people were awake. The loss of life, therefore, was small in comparison with the magnitude of the shock and its otherwise devastating effects.

6. Mr. S. E. CHURCHFIELD, representative of the Assam Oil Co., dealt with the earthquake as experienced at Digboi, Assam. Details concerning time, duration, and intensity were furnished. The direction of movement was North to South at first, changing to Northeast to Southwest when the intensity increased, and finally went Northwest to Southwest. The vertical movement was not more than 3 to 4 inches, the horizontal 4 to 6 inches, and the vibrations were about 10 cycles per second. Shortly after the cessation of the main tremors, sounds resembling bomb explosion were heard coming from a northerly direction. According to one observer two flashes of light were seen to the north which were not due to lighting. Churchfield then dealt with the local geology in relation to the earthquake. No marked geological changes had been observed except in the eastern end of the field, in the alluvial area, where a number of fissures were seen opened and some sands and water ejected out. The earth movements did not affect the uncased oil wells. A number of houses whose foundations were on sound rock (though relatively unconsolidated) suffered heavy damage, while others on alluvium were undamaged. Details of the nature and extent of damages to the Company's property were furnished. The cost of damage was estimated at over Rs. 9 lakhs. No damage was caused to drilling wells, and in the case of some producing wells there were some damages due to parting of casing, and cracking of the concrete foundation. No change in the production of fluids in any part of the field was observed. Other damages included some repairs to the refinery and installation. No casualties occurred in Digboi.

Several photographs showing the damages were exhibited. A table of the after shocks observed using home-made seismograph was also presented, together with a graph showing the number of after shocks per day and their maximum intensity from August 15 to November 13, 1950.

7. Mr. V. H. BOILEAU, Petroleum Geologist of the Geological Survey of

India, gave a general survey of the geological features of Assam and discussed several points of interest in connection with this great earthquake. According to him, there was a vast tearing movement along the front of Assam Himalayas, and this tearing movement, combined with pressure across the main Himalayan trend, had continued intermittently in to geologically recent times. The principal belts of destruction lay in the hills. The young tertiary rocks of the arcs of the hills between North Lakhimpur and Tezpur had moved forward more freely, into a saddle of the concealed ancient rocks, while the Subansiri Gorge sector had been held back by a shoulder of the buried mass. Aerial surveys by the investigating field parties showed that while land slides were common in the thrust zone, their extent decreased upstream in both the Subansiri and Dibang valleys.

The Geological conditions in relation to after shocks were also discussed. Dealing with the distant records of earthquake, Boileau remarked that an interesting feature of the Assam Earthquake was that they were often felt in Southwest Bengal and within a moderate distance of the hills of Assam and Tripura and the alluvial region of East Bengal —but not with such distinctness in the intervening belt. Local structures seemed to have had an influence on the path of the waves. The movement at Burdwan appeared to come from the north instead of a more northeasterly or easterly direction. This was so probably because the ancient rocks were cut off close on the northern side, along the trend of the boundary fault of the Raniganj coalfield, and the waves were refracted at that junction of unlike rocks.

Finally, dealing with safety precautions, Boileau stated that by demarcation of the definite areas or alignments which for purely geological reasons were especially liable to damage, warning could be issued against the building of important structures within such areas, or if the constructions could not be avoided, suggestions given as to how the damages could be minimised. In planning the major constructions for the great multipurpose dams projected in many parts of India, the potential occurrence and intensity of earthquakes and the allowance to be made for them in actual design, were now receiving active attention.

8. Shri L. P. MATHUR, Geologist, Central Water and Power Commission, presented data concerning the observations on after shocks, directions of movement, reports of sounds, and extension of serious damages, formation of fissures, sand veins, and subsidence. He also dealt with the damage to roads, railways, building etc. Mathur himself happened to be staying at Dibrugarh on that memorable evening of August 15, 1950, when the place was violently shaken. Later, he formed one amongst the party which toured the affected areas. Speaking on the landslides, he stated that a tract about 200 miles in length and about 60 miles in width was involved, and from the aerial reconnaissance it appeared that 6000 sq miles of that tract, was affected by severe landslides. Taking an average depth of 10 ft, he had estimated that the total volume of earth removed was of the order of 6×10^{10} cu yards. The effect on the rivers, both directly and indirectly caused by the earthquake was discussed.

9. Shri G. R. GARG, Director, Central Water and Power Commission, presented data regarding the effect of the earthquake on topography, and on the regime of the rivers. Amongst the many other effects he mentioned, it was interesting to learn that some tube wells were cut clean at a depth of about 20 ft, and in one locality an artesian well, about 400 ft deep, had choked up immediately after the earthquake, and the normal flow revived after 16 hours of stoppage.

As a result of extensive land slides big blocks had fallen in the Subansiri and along the tributary rivers. Most of the blocks burst within a few days after the earthquake, causing extensive floods. An aerial photograph revealed the existence of a huge block of rock about 4 miles in length and $\frac{1}{4}$ mile in width, in the head waters of the Tidding river 80 miles up the river from Sadiya. The bed of the rivers had considerably silted up, and many had changed their courses too. Those changes were only transitory in some cases while in others it was going to be more or less permanent. Details were given concernin

the regime of the Brahmaputra and the Subansiri tributaries. Regarding silt contents in the rivers, two observations have been made at Dibrugarh after the earthquake, and the silt discharge was 30 per cent by volume. A month later, the silt was 11 per cent. Normally, during winter, waters of all the rivers and channels in that area remained clear, but during 1950 it was muddy in all, and silt movements were going on.

A detailed statement was furnished regarding damage to the roads. A devastating effect took place in the Assam Trunk Road for 2½ miles in length, between Dholla and Saikhoa and the ground there was badly shattered and sunk at many places. Six wooden bridges had also broken down beyond repairs.

10. Capt. C.H.T. SEIGNIOR, Marine Superintendent, of the Rivers Steam Navigation Co., Ltd., gave an account of his observations during a tour of many hundreds of miles covered by car, jeep, launch, dugout, motor boat (both power and hand propelled), elephant, and on foot, between 19 February to 3 March 1951. According to Seignior, the bed of the Brahmaputra had been raised by an average of 5 ft and that the Dibrugarh town and surrounding country would, therefore, be flooded from two to five feet depending on the extent of the rains. As regards the apprehension about a huge lake which was reported to be in existence and threatening serious floods, he stated that the aerial photographs had shown that only a few minor lakes did in fact exist. The largest one was about 80 miles above Sadiya, above the Lohit river, 4 miles long by a ¼ mile wide. He thought that the existing bed of the river could carry all the water should the dam burst.

Considerable changes might occur with rains. Large volumes of silt, and a huge number of trees were brought down by the Brahmaputra. An optimistic estimate was that the normal conditions in the Brahmaputra were not likely to materialise within two to four years while other opinions gave period of not less than 10 years. Although opinions differed on the actual duration, there was, however, no doubt that in due time the Brahmaputra would re-establish her old regime. Only 4 river gauges were maintained by the Public Works Department, and more would be necessary for the collection of cross sections, silt discharge, etc. When one took into account the effect of the mountain ranges from a few hundred to 15,000 ft in height, and for some hundred of miles in length, which had been affected, the huge volume of solid and trees involved in the river discharge could be easily appreciated. The Dibang river had changed its course owing to the close of its outfall. In that area, there was a startling example of how just one tree could act as a trap for others, building up the most formidable barrier and becoming not only a danger to navigation but the cause of diversion of the entire river course.

Off Pasi ghat, the speed of the current had been estimated from 30 to 50 miles per hour for some time after the earthquake. This was no doubt phenomenal. The waves of the area were estimated at 15 to 20 feet high.

Dealing with the Subansiri, Seignior stated that the damage caused by landslides owing to the earthquakes on August 15, 1950, did not burst until 4 days later. The devastation in the area from the floods was very great. Fortunately a local Tea Planter who had flown over the area had issued warning ; otherwise the loss of life would have been much more serious from the floods. The river itself had changed its course.

Several other points of interest regarding the regime of rivers and other observational details were furnished by Seignior.

11. Shri S. P. CHOUDHURY, Engineer of the Public Works Department, Government of Assam, furnished details regarding the damages at each of the worst affected areas, *i.e.*, Jorhat, Sibsagar, Dibrugarh Sub-division and town, Sadiya, Saikhowa-Rongdoi Road, Lohit Valley Road, Abor Hills, Kebo Pasighat Road, and North Lakhimpur. A map was also presented showing the various locations. The nature and extent of the damages to the buildings, roads and Government Embankments etc., were outlined. It was estimated that it would take more than 150 lakhs of rupees to effect repairs and restoration for damages caused by the earthquake and subsequent floods.