regulating the birth of babies is generally accepted. In India the conditions are still not quite favourable for universally welcoming this wild goose that lays no eggs.

The North Bihar Earthquake of the 15th January, 1934.*

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ON Monday the 15th January 1934, at about 14 h. 14 m. (I. S. T.), Calcutta experienced an earthquake shock of fair intensity which lasted for over three minutes. Buildings swayed, freely hanging objects oscillated vigorously, and even persons in motion were affected. From past experience of earthquakes in Calcutta, it was clear that this one must have effected considerable damage to life and property at the place of origin. News from the country was available only next morning, showing that Patna, Monghyr and Jamalpur had suffered severely. News from the most affected region arrived only two or three days later. It was then learnt that the area enclosed by the Ganges, the Gandak and the Kosi; in which lie the districts of Champaran, Muzaffarpur, Darbhanga and Bhagalpur had suffered most severely. Authentic news was difficult to obtain from here as well as from the adjoining parts of Nepal, as the communications—roads, railways and telegraphs—were cut off and took some days to restore even partially.

The shock was felt throughout the greater part of the Indian Empire, in the Punjab on the west, in several places in the Madras Presidency on the south, and on the Arakan coast to the east. Seismograph stations reported that the main shock lasted for over 20 minutes and that some 13 milder shocks were registered during the night of the same day. Several after-shocks of varying intensities have continued to be registered since then. As is usual with all violent earthquakes, such after-shocks will probably occur for a few months to come.

NATURE AND EXTENT OF THE DAMAGE.

It is yet too early to estimate the loss of life and property caused by this sudden catastrophe. The official reports have already put the estimated loss of life at over 7,000. The number of injured is also large. The loss of property can be measured only in crores of rupees. The prompt and vigorous relief measures taken by the Government in co-operation with un-official agencies have largely prevented the danger of epidemics, which would otherwise have resulted from the scarcity of drinking water and lack of sanitation.

In the most affected area, the earthquake was attended by the appearance of large rifts or cracks at the surface. Some of these are one to two furlongs long and a foot or more wide. Through these were forced up soft, water-bearing sands and silts and spouts of water. Many wells have been filled with sand or have dried up.

In alluvial areas, the appearance of cracks attended by spouts of water and sand is a common phenomenon during earthquakes. As the surface waves travel along, the layers composing the alluvium are thrown into troughs and crests, soft silt and quick-sand being forced up along openings which might appear in the crests. When the water ceases to flow, crater-like openings are sometimes left in the piles of sand. As some of the layers are rich in organic matter—peat-beds and buried animal remains—they may be expected to yield hydrogen sulphide and hydro-carbon gases when suddenly exposed to the atmosphere. Waters forced up from depths of several tens of feet will also be warm when they first reach the surface. Reports of warm sulphurous waters (which, however, have not been subsequently substantiated) have led the people to a mistaken belief in subterranean volcanic action in this area.

In the Tirhut division the track of the Bengal and North-Western Railway has in many places been buckled, twisted or torn apart. Telegraph and telephone wires have been snapped. Several bridges and culverts have collapsed, and transhipment of passenger traffic has been necessary over several important bridges. In several towns, *e.g.*, Monghyr, Jamalpur, Purnea, Muzaffarpur, Darbhanga, Motihari, Sitamarhi, Samastipur, etc., most of the houses are in ruins. Some of these seem to have been almost

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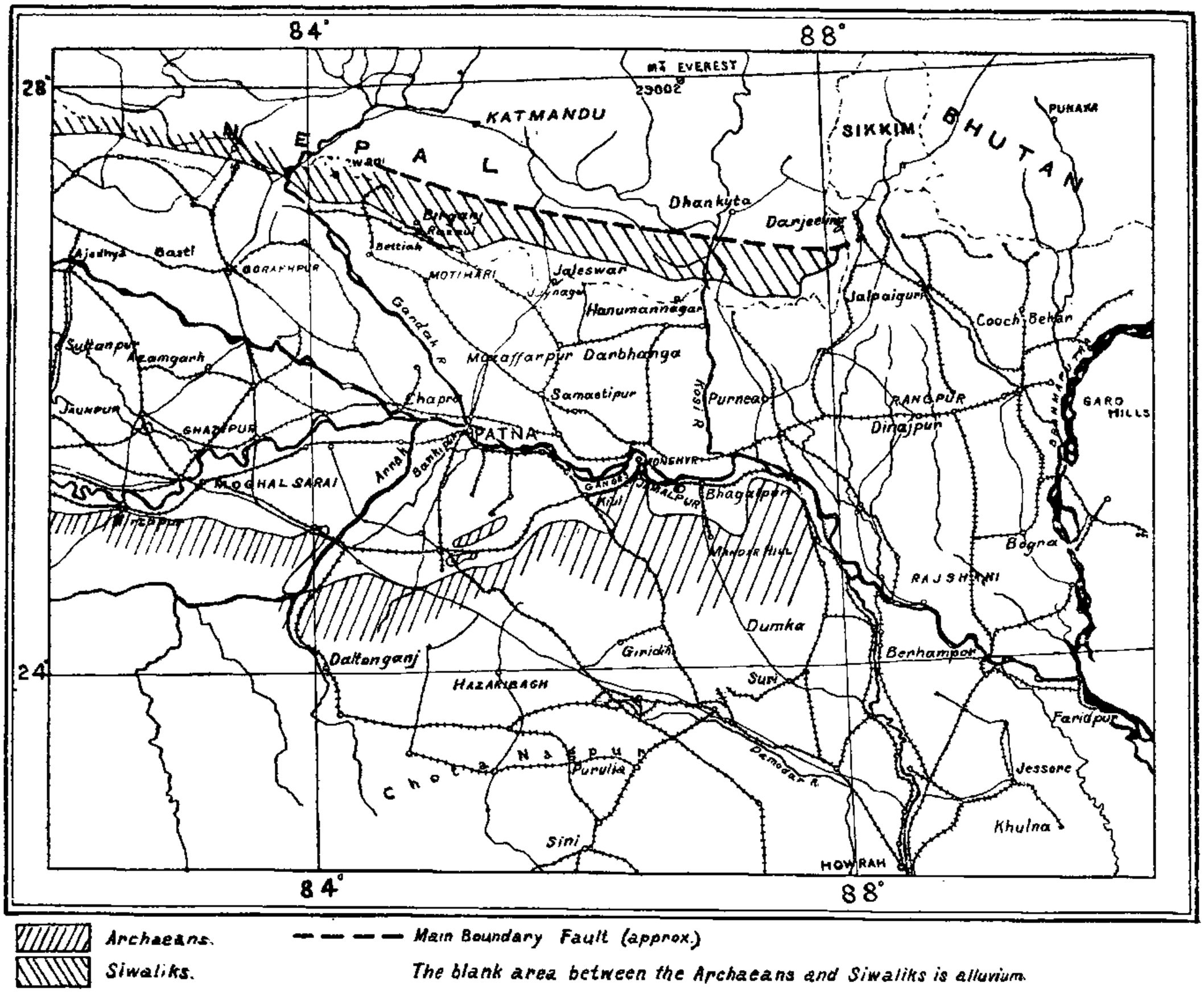

entirely destroyed. About half the number of sugar factories of this area are reported to have been damaged beyond easy repair so that the sugarcane crop is in danger of considerable loss for lack of facilities for crushing. The country-side has been heavily inundated or silted up.

THE EPICENTRAL AREA.

A scrutiny of the reports appearing in the newspapers makes it clear that the most severely affected region lies in the Sitamarhi and Madhubani sub-divisions, lying on the Nepal border between longitudes 85° 0′ and 86° 30′. Katmandu and the neighbouring towns in Nepal are also known to have suffered heavily. The region between Motihari and Monghyr has also been severely affected. It seems therefore that the epicentral area may be roughly located either along the Nepal border or in a tract extending in a N.-W.—S.-E. direction through the districts of Muzaffarpur, Darbhanga and Monghyr. We must await the report of the Geological Survey officers, who are still in the field, before we know of this with any precision.

It will be noticed that the town of Monghyr has been destroyed almost entirely, while its neighbour Jamalpur has suffered severely. This is apparently puzzling and might lead one to infer a focus under Monghyr but different explanations of the phenomena may be possible. Darjeeling is also reported to have been badly shaken but it is now possible to say that the shocks there were not due to the presence of a minor epicentre.

THE ORIGIN OF THE EARTHQUAKE.

It is now known that some 10,000 earthquakes occur per annum over the whole globe, and are recorded by some seismograph station or other. Of these, barely one per cent. may be felt by the people in the immediately adjoining region. Only a few are violent enough to cause destruction of life

and property. The present earthquake undoubtedly belongs to this last group.

By far the great majority of earthquakes are due to the relative displacement of the earth's crust. There are two major tracts on the surface of the globe which are frequently subject to seismic activity: (1) the Circum-Pacific belt or the coastal region surrounding the Pacific Ocean, and (2) the Alpine-Himalayan system of mountain chains. Both these are regions of conspicuous instability. The mountains of the Circum-Pacific belt as well as the Alpine-Himalayan system are comparatively young and are flanked by deep troughs.

Dealing specifically with India, it is well known that the Himalayas together with the Baluchistan arc on the west and the Burma-Malaya arc on the east constitute a region of frequent earthquakes. There are some well marked zones of overthrust or reversed faulting in the Himalayas. The southernmost and youngest of these overthrust zones lies at the base of the Upper Tertiary sandstones and conglomerates known as the Siwalik formations. This overthrust zone is known in Indian Geology as the Main Boundary Fault, as it is a very conspicuous feature along the whole length of the Himalayas from the Punjab to Assam. The Himalayas are constantly being disintegrated and eroded, the resulting material being loaded into the trough of the Indo-Gangetic alluvial region to the south by means of a large number of rivers. According to the principle of isostasy, the crust of the earth floats, so to say, on a sub-stratum at some depth, and the transfer of material from one block to its neighbour causes a relative movement between them. The block which loses the material, *e.g.*, the Himalayas, tends to rise, and the block which receives the material, *e.g.*, the Gangetic alluvium, becomes heavier and tends to sink. A constant state of strain is thus established, which must now and then be released by the relative movement of the affected blocks along a fault zone. These movements set up vibrations which travel outwards as waves and cause earthquakes. It is known that the Main Boundary Fault is the chief zone along which displacements take place in the Himalayan region.

The position of the Main Boundary Fault is roughly known along the road from Raxaul to Katmandu, being about 20 miles to the north of the former town. It proceeds thence eastwards beyond Darjeeling, its outcrop being seen a little to the south of that town. In the intervening area its position can be roughly determined by interpolation, as the whole of Nepal is yet to be mapped geologically. It seems therefore not unlikely that, of the two possibilities mentioned earlier in this note, the epicentral region may overlie the section of the Main Boundary Fault lying to the north of Sitamarhi and Madhubani.

The destruction of Monghyr may probably be attributed to the geological structure of the locality. Monghyr lies on alluvium resting on a spur of Archæan rocks projecting northward under it. This spur has evidently forced the Ganges to make a conspicuous bend convex towards the north, in which the town lies. So the town is situated on a comparatively thin fringe of alluvium reposing against a slope of ancient rocks. It would seem that the waves proceeding from North Bihar were liable to reflection and interference at the junction of two formations of such different characters as alluvium and ancient metamorphic rocks, the inhomogeneity and softness of the alluvium being responsible for the excessive vibration of the foundations of the town.

PREVIOUS EARTHQUAKES IN NORTH BIHAR AND NEPAL.

Newspapers seem to have created an erroneous impression that this region has not been visited by earthquakes before. A reference to the catalogue of Indian earthquakes compiled by Dr. T. Oldham (*Mem. Geol. Surv. Ind.*, **19**, Pt. 3. 1883) shows that the following earthquakes affected the area during the last century:—

3rd August, 1819. Tirhut. Felt in different places. Not severe.

29th October, 1826. Nepal, etc. A great shock followed by eight minor ones. Several houses fell in Katmandu and Patna.

26th August, 1833. Nepal and North-east India. Very violent. Heavy damage in Katmandu, Tirhut, Chapra, Buxar, etc. Several shocks followed for over two months.

10th August, 1843. Darjeeling, Tirhut, Patna.

23rd May, 1843. Terrible shock at Katmandu which destroyed a large part of the town. Felt at Calcutta, Darjeeling, Monghyr, Jubbulpore, etc.

7th July, 1869. Tremendous shock at Katmandu attended by much destruction of life and property.

A party of officers of the Geological Survey of India is studying, in the field, the scientific aspects of the earthquake. Their investigations are expected to occupy several weeks, and the correlated results to be published by the department at an early date.

North Bihar Earthquake of January 15, 1934.

By Dr. S. K. Banerji, D.Sc.

1. INTRODUCTION.

THE earthquake which occurred at about 2–15 P.M. (I.S.T.) on the 15th January 1934 in North Bihar and Nepal is one of the most disastrous and most widely-felt of which we possess any record, and is comparable in severity with the Great Assam Earthquake of 1897 and the Kangra Earthquake of 1905. It has demolished buildings and bridges, damaged railway lines and roads, caused numerous fissures in the ground through which spouted forth water or sand and thus flooded or covered with sand extensive areas. The appearance of a tract extending over about 100,000 square miles was completely changed within the brief interval of 3 or 4 minutes. Thousands were killed or injured and those who survived were thrown into a state of panic. The movements of the ground were felt over almost the whole of northern and central India and as far south as Poona and Bombay.

From the many casual observations, which have been made, it is reported that the 'fault' in the crust very likely stretches the entire way from Motihari to Monghyr, a distance of about 135 miles. There is probably also a second 'fault' beginning somewhere in the middle of the first one and running at an angle to it in the direction of Purnea. Until, however, the map of isoseismal lines is available, it is not possible to define precisely the epicentral tract. For the present, we may consider the epicentral tract to be bounded roughly by an ellipse as shown in Fig. 1. The following epicentral

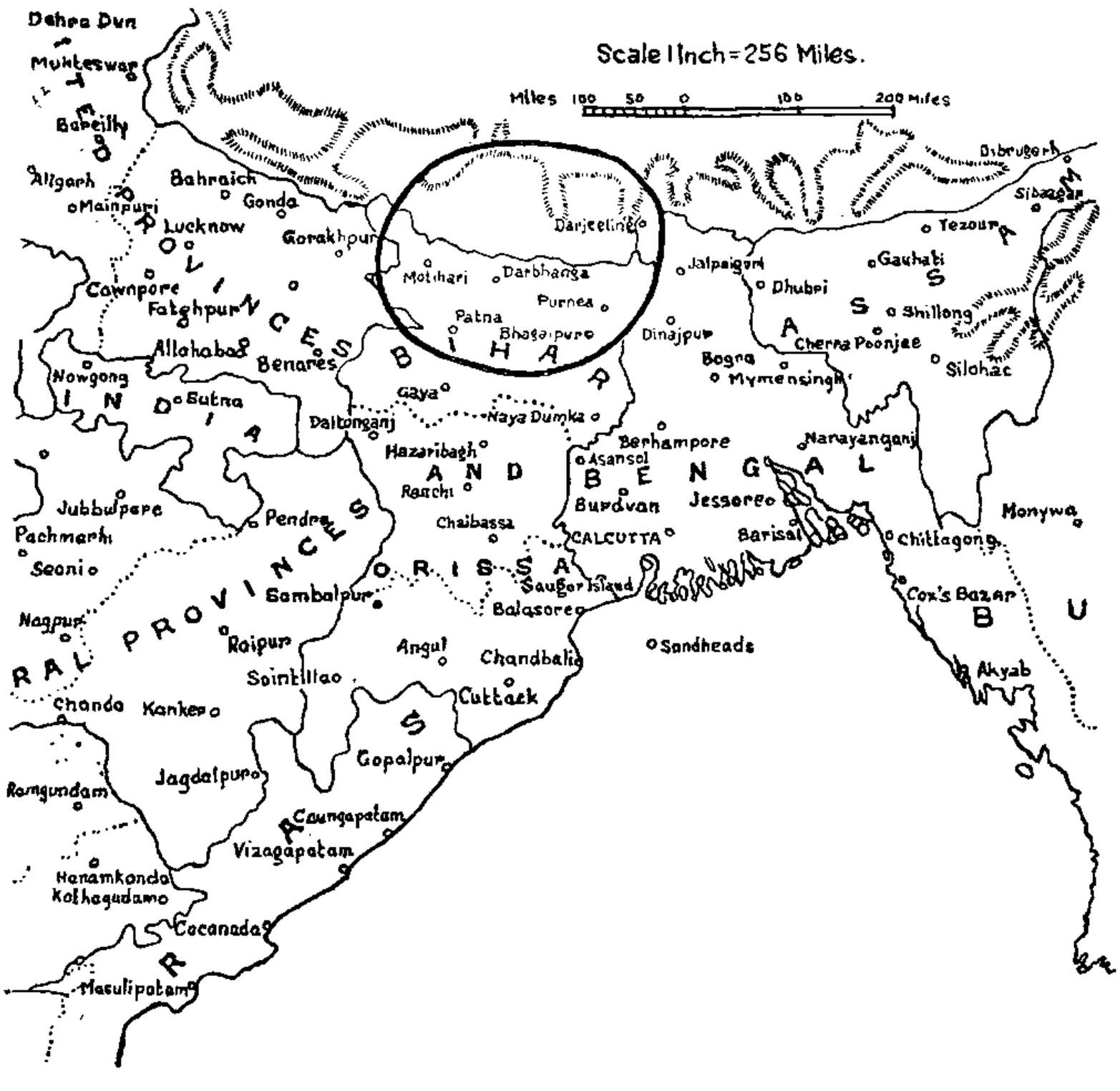

Fig. 1.