TERTIARY PALAEOGEOGRAPHY OF NORTH-EASTERN INDIA

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ABSTRACT

In this paper, an attempt has been made to draw a picture of the geographical condition of North-Eastern India in the Tertiary period based on recent data. The pre-Tertiary conditions have been briefly described. In the Eocene about half of the Assam Plateau and the whole of the Brahmaputra Valley were under the sea to which the antecedent rivers, the Brahmaputra, the Subansiri, the Manas, and the Sankosh brought their loads of sediments from the region of the Great Himalayas and the Lesser Himalayas through independent channels. At the end of the Oligocene, the whole of Assam was heaved up and the sea receded far to the south. In the Miocene, the sea gradually readvanced northwards but by Middle Miocene, the Brahmaputra changed its channel and occupied the foredeep in front of the Himalayas, brought about by its latest upheaval. The other antecedent rivers now joined the Brahmaputra as tributaries. The Bokabil beds are topped by estuarine beds where mammalian fossils have recently been found. The Tipams, according to the author, are mostly fluviatile and of Miocene age.

INTRODUCTION

So much has been written about the Tertiaries of Assam that one hesitates at the thought of adding anything fresh in the matter. Yet the exploitation of the oil resources of the State is constantly bringing up fresh materials from under the surface to add to our existing fund of knowledge. It is indeed one of the very happy combinations where exploitation of economic minerals had led to elucidation of the past geological history relating to an area. For our present knowledge about the geology and structure of north-eastern India great credit is due to the oil geologists of Assam, both past and present.

PHYSIOGRAPHY

Before the palaeogeography of the Tertiary period is discussed, it is necessary to set out the present physiographical units of north-east India and, in a broad way, the stratigraphy of each unit. Seven units can be recognised. (i) The Himalayan mountain region bordering on the north. (ii) The mountainous region of the north-east (Mishmi Hills) which shuts the valley. (iii) The hilly region of the south-east—Naga Hills, composed of Tertiary and Mesozoic rocks. (iv) The Assam Plateau to the south-west consisting of the Garo, Khasi and Jaintia Hills and the detached Mikir Hills. (v) The Brahmaputra Valley. (vi) The hilly region of North Cachar and Mizo Hills made up of Tertiary rocks. (vii) The Barak Valley.

The Himalayas are divided into three longitudinally parallel zones known as the Foothills, the Lesser Himalayas and the Great Himalayas. The Himalayan foot-hills are composed of the Assam equivalents of the Siwaliks, namely the Dihings, the Tipams and the Upper Surmas, and rarely exceed 900 metres in height. Over the Tipams and Surmas are thrust the metamorphic Dalings and Darjeelings, containing Gondwana rocks, which constitute the Lesser Himalayas. The Lesser Himalayas rise to a height of 3,000 metres.

All these ranges are cut through by the Brahmaputra, the Subansiri, the Manas, and the Sankosh.

The Mishmi ranges of the north-east are composed mainly of Pre-Cambrian rocks which are thrust over the Tertiaries along the Miju thrust running WNW-ESE.

The hilly region to the south-east is composed of folded sedimentary rocks from Triassic to Pleistocene which are overthrust in a north-west direction in an imbricate fashion on the Pleistocene and recent deposits of the Brahmaputra Valley. The Naga thrust is the western-most of a series of these thrusts trending NE-SW and nearly coincides with the south-eastern limit of the Brahmaputra Plain.

Situated on the south-west, the Assam Plateau comprises the Garo Hills, the Khasi and Jaintia Hills and the detached Mikir Hills. It is mostly composed of Pre-Cambrian metamorphic and igneous rocks except on the southern edge where there is a veneer of Cretaceous and Tertiary rocks. Now it is an uplifted peneplain, where the rejuvenated rivers flow through narrow gorges. The old peneplain presently dissected into a landscape of youth is easily recognised by the even sky-line corresponding to a widespread and uniformity of levels at about 1,200 metres. The plateau slopes in all directions and the drainage is radial.

The Brahmaputra Valley, 600 km long, lies between the Himalayan foot-hills on the north and Naga Hills and the Assam Plateau on the south. The width of the valley varies from 106 km to 274 km. The gradient of Brahmaputra varies form 12 cm/km between Dibrugarh and Tezpur, to 5 cm/km between Tezpur and Gauhati and to 9 cm/km between Gauhati and Dhubri. Its braided channel, nearly level gradient and the wide flood-plain speak for a late stage of maturity of the river but the land-forms belie this. This is because of the chequered life history of the river.

The hilly regions of North Cachar and the Mizo Hills are dealt with together. The hilly regions of North Cachar are composed of Tertiary rocks and the Barail Range which links the Naga Hills with the Shillong Plateau serves as a divide between the drainage to the north and to the west. The Barak Valley is the upper portion of Surma Valley, the northern boundary of which ends abruptly against the foot of the Khasi and Jaintia Hills. The south-east boundary is of a different character; long spurs of high hills project from the Mizo and Tripura Hills and between them are broad valleys diversified with many low, isolated hills and low ranges. This is the result of the strata having been folded into N-S wave-like corrugations giving rise to alternations of hills and valleys.

STRATIGRAPHY

The oldest rocks are exposed in the central portion of the Assam Plateau and are composed of crystalline and Pre-Cambrian metasediments with interbedded lava flows. A section west of Mawphlang (23° 27′ 0″N; 91° 43′ 30″E) shows the development of two distinct lithostratigraphic units of Shillong Series—a Lower Argillaceous Stage and an Upper Arenaceous Stage.

The beds in the upper stage appear to have been laid down in a shallowing sea, as the quartzites often show current-bedding and ripple marks. They are well folded as exposed on the Shillong-Jowai road south of Nongthymai. Apparently, the whole series was uplifted by some orogenic movement during which time intrusion of granite took place. Except that these rocks are Pre-Cambrian, no precise data about their age are available. By radiometric method, Sarkar, Polkanov, Gerling and Chukov (1964) determined the age of coarse muscovite from a E-W trending mica-schist of the Shillong Series at 472

million years and commented that the regional metamorphism of the series took place during the Ordovician time. Until more radiometric age determinations are made by other methods, the determined age cannot be taken, especially as there is at present no evidence of any past tectonic movements during the Ordovician time for the regional metamorphism assumed.

No marine Palaeozoic rocks are seen in the whole of Assam whether in the exposed Shillong Plateau or in the basement concealed under the alluvium, except in the north-east corner of Assam, in the Ranganadi Valley from where KRISHNAN (1968, p. 55) records that Gondwana plant-bearing beds are associated with marine formations containing *Spirifer*, *Chonetes*, *Eurydesma* etc. The occurrence of this curious type of thick shelled pelecypoda, *Eurydesma* is very significant. The *Eurydesma* fauna is a fauna of cold seas, characteristic of the old shores of the Gondwana continent to which glaciers descended. In the heart of Assam only at Singrimari, on the western border of Garo Hills, continental Gondwana of Barakar Stage (Permian age) has been noticed. On the northern borders, however, such continental rocks with characteristic plant fossils and coal occur over a long narrow belt in isolated places from Bhuban to Aka Hills where they lie thrust over Tipams and Surmas (KRISHNAN, 1968, p. 247). These are remnants of a paralic deposit on the southern coast of the Tethys.

During the millions of years from the Pre-Cambrian to Permian the high ground to the south was undergoing active denudation.

The Tethys which stretched as far south as the Ranganadi Valley by Permian time reached the Burmese Arc by Triassic if not earlier, for the oldest rock exposed in the Naga-Arakan Yoma range belong to the Axial System (KRISHNAN, 1968, p. 346), the lower part of which is Triassic. On the Assam-Burma border of Manipur occurs a series of black slates, sandstones and quartzites which are referable to the Axial and, therefore, of Triassic age. Rivers discharging into the Himalayan Tethys on the north and the Burmese Arc on the south continued to denude the high ground extending from the Assam range on the west to the Brahmaputra Valley to near base level.

The basaltic lava flows that welled up through fissures and local vents in late Jurassic time (SENGUPTA, 1966, p. 1009) in the southern edge of the Shillong Plateau and in the Mikir Hills did not bring about any great physiographical changes. Like the Himalayan Tethys, the Burmese Arc sea was also a geosyncline and continued through the Jurassic; but in the little explored area of the Assam-Burma border, Jurassic rocks have not so far been discovered.

A most remarkable geological event in the Cretaceous was the world-wide marine transgression known as the "Cenomanian Transgression". The sea appears to have advanced from the south-west and having flooded the Bengal basin (Bolpur and Ghatal Formation) arrived at the southern edge of the Shillong Plateau in Maestrichtian time. But more probably, since it was an eustatic movement, the pre-existing Burmese sea also encroached on the southern edge of the peneplained mass. The shore-line of this transgressive sea ran in arcuate fashion from the south-east corner of Garo Hills District to Sohrarim, north of Cherrapunjee, and then south-east to Dawki. Eastward its limit is marked by the exposures of the Disang Series, lower part of which is considered as Upper Cretaceous. In the Burmese sea, Barremian conglomeratic limestone containing *Orbitolina birminca* was deposited at the Noge Bum in the Hukong Valley and limestone at Ukhrul in Manipur. An ophiolitic phase is noticed in the nickeliferous serpentine veins in the Ukhrul limestone. The Cretaceous, south of the Shillong Plateau, is littoral and neritic

and the basal conglomerate is dichronous. The predominant member of the Mahadek Formation (Maestrichtian) is a glauconitic felspathic sandstone, fossiliferous at the top. The sandstone is made up of sub-angular and more or less rounded grains derived from the gneissic country of the Plateau. The Langpar Formation is Danian in age is a combination of shale and sandstone with calcareous intercalations. The Langpar Formation overlaps the Mahadek Formation. The beds have gentle dips on the plateau but plunge steeply down on the southern edge under the alluvial valley to the south. Whether this marks the hinge-line between the shelf and the geosynclinal facies is not known.

In Laramide time, due to orogenic movement, the Burmese sea itself was divided into an Assam Gulf on the west and a Burmese Gulf on the east, the divide appears to be a geoanticline in the core of Arakan Yoma.

In Figure 1 an attempt has been made to depict the geographical conditions of North-eastern India at the end of Cretaceous.

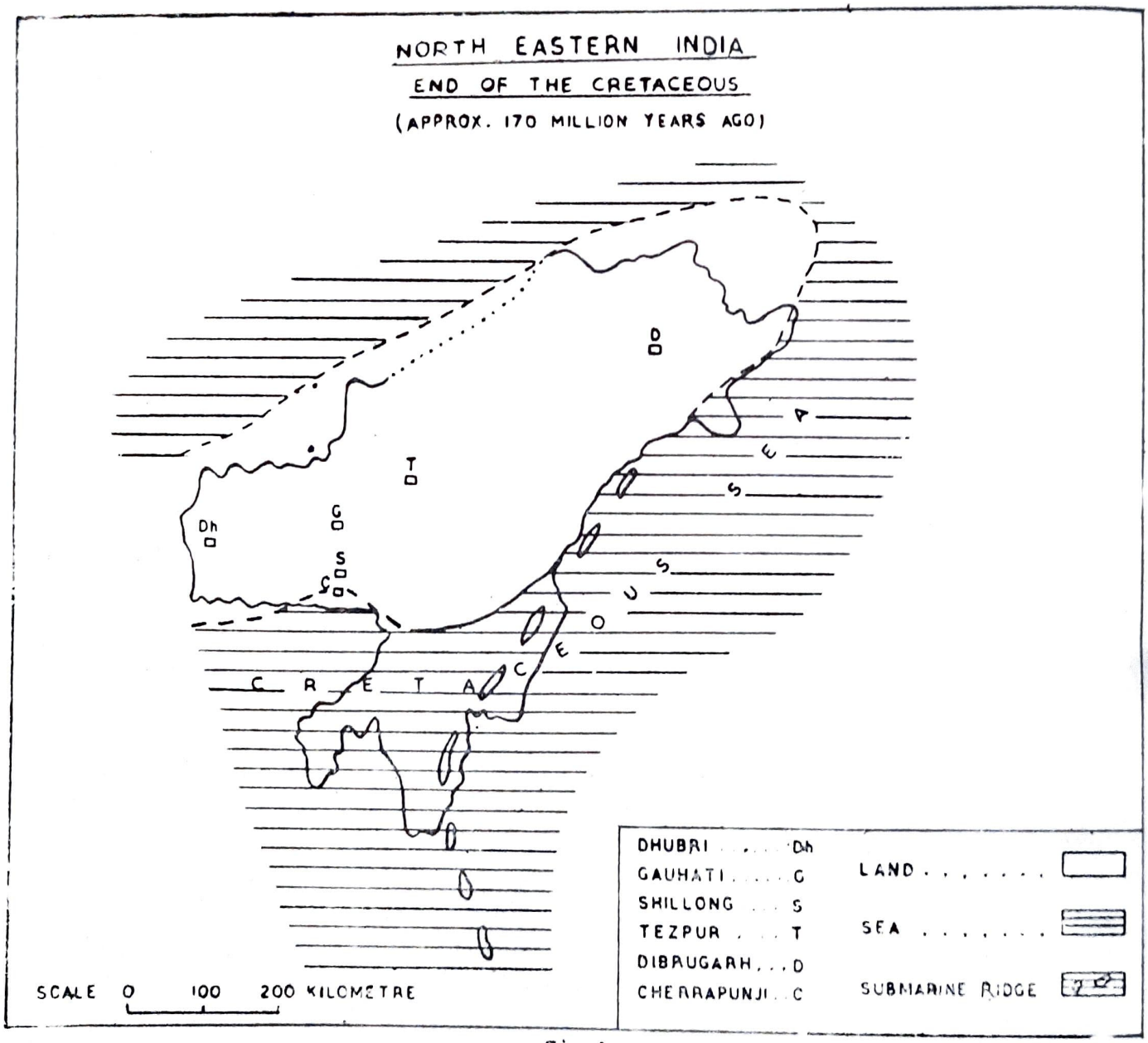

Fig. 1

At the close of the Cretaceous, the sea receded from the Shillong Plateau to the laittude of Therriaghat (25° 11' 0" N) only to readvance in the Eocene.

PALEOGEOGRAPHY OF THE TERTIARY

PRE-EOCENE

In the Tertiary period, sedimentation took place in two basins of different types—a miogeosyncline (KUENDING, 1960, pp. 56-57) on the shelf and an eugeosyncline covering the Assam Gulf and most of the Surma Valley up to the foot of the Assam Plateau. The deposits on either side of the hinge zone are of sharply contrasting types. A hinge belt has been defined morphologically as a zone of scarp-forming, and its high mobility is characterised by much faulting along the belt of adjustment between the relatively stable shelf and the geosynclinal trough of more rapid subsidence (WEEKS, 1952). The angle of slope may vary from 90° on the reefs to 2°. Deep drilling for oil in the Bengal basin has established the existence of a hinge zone trending "approximately N 30° E through the East Calcutta and Ranaghat areas and dips at an average of 2,000 ft. per mile which is about 14 times the dip of the limestone (Sylhet Limestone) in the shelf area. This zone (stable shelf zone) is characterised by very gentle dip about $1\frac{1}{2}°$ at 'D' reflector level i.e. top of the Sylhet Limestone (SENGUPTA, 1966, p. 1009). Speaking of the Eocene Limestone, EVANS (1964, p. 82) says that the Eocene hingeline separating the shelf facies from the geosynclinal facies, runs from near Calcutta to near Mymensingh, and in Upper Assam it must lie somewhere in the Naga Hills, probably not at very great distance south-east of the Brahmaputra alluvium.

The eugeosynclinal facies is composed of shale with thin sandstone and is called the Disang Series. This series is exposed in the eastern parts of Surma Valley in part of the North Cachar Hills in Manipur and in the Naga Hills.

During the temporary withdrawl of the sea from the South Shillong Plateau in the Palaeocene time, a luxuriant vegetation flourished in a humid tropical climate on the low land, giving a modern aspect in which palms can be distinctly identified. The remains of the vegetation accumulated in the swamps give rise to the valuable coal seams of the Laitryngew field. The Laitryngew-Mawkma palynological assemblage consists of spores and pollengrains, with a few fungal and algal remains, but there is no record of any hystrichospherids, dinoflagellates or microforams. The overall vegetational assemblage suggests that a stretch of coastal swamp lay adjacent to the depositional areas.

The sea which had retreated to the position of Therriaghat advanced northwards in early Eocene time and covered the central Shillong Plateau and reached 16 Km north of Shillong, where we find the Um-Raling coalfield at Barapani. Eastward it extended continuously over the Brahmaputra Valley and westward it covered Tura and beyond. In the warm shallow waters of this Eocene sea, limestones were deposited on the continental shelf extending from near Tura to north-east Assam. Only the outcropping deposits at Siju, Therriaghat, Mawmluh, Garampani and south of Mikir Hills are now visible. The coal seams of Jowai and Mikir Hills are of Lakadong age.

In the Brahmaputra valley, the basement had been denuded sufficiently enough for the Eocene sea to readvance beyond the limits of the Cretaceous sea. Deep drilling for oil has revealed the presence of Sylhet Limestone over the basement under a thick cover of younger Tertiaries. Of these boreholes, the Tengakhat (Lat. 27° 25′ 30″, Long. 95° 08′) one is the northernmost, and it is safe to assume that the Eocene sea extended as far north as Tengakhat if not beyond. The Eocene shore-line, therefore, trends E-W from Tura but some distance east of Shillong turns NE through Tengakhat to north east of Assam.

Before an outline picture of the physiography of the country at the dawn of Eocene can be drawn, it is necessary to find out the sources of the Tertiary sediments and the agents

of their transportation to the sea. In Permian, the rivers drained the land that lay to the south—a land that has been undergoing active denudation since the Pre-Cambrian. From Trias drainage was both to the north and south-east. With the initial orogenic movement of the Himalayas in the Upper Cretaceous, the Tethys was being thrown into furrows and basins and by the beginning of Eocene, the rising ground brought into being a new drainage system and the rivers coursed to the south. In his address to the First Annual Session of the Geological Society of Assam, BORODAH (1969) has outlined the history of the Brahmaputra with those of the Subansiri, the Manas, and the Sankosh, all antecedent rivers, and the role they have played in the formation of the Assam Tertiaries.

EOCENE

The Eocene shore-line, as already pointed out, ran east and west from just north of Tura to far east of Shillong and then turned north-east to the eastern boundary of the state. Within Assam, in the country west of Tezpur, only outcrops of the Pre-Cambrian rocks are seen north of the above shore-line either in continuous outcrops or as outliers in the recent alluvium. The antecedent rivers, the Brahmaputra and the Subansiri, drained the Tethys Himalayan zone, the Great Himalayas and the Lesser Himalayas. Of these, the last being composed of Dalings, Darjeelings and Buxas and possibly a narrow zone of the Shillong Series before they discharged into the Eocene sea. The Manas and the Sankosh also traversed through the above zones of the Himalayas and possibly a broader zone of the Shillong Series.

Figure 2 roughly depicts the geographical conditions in the Eocene period.

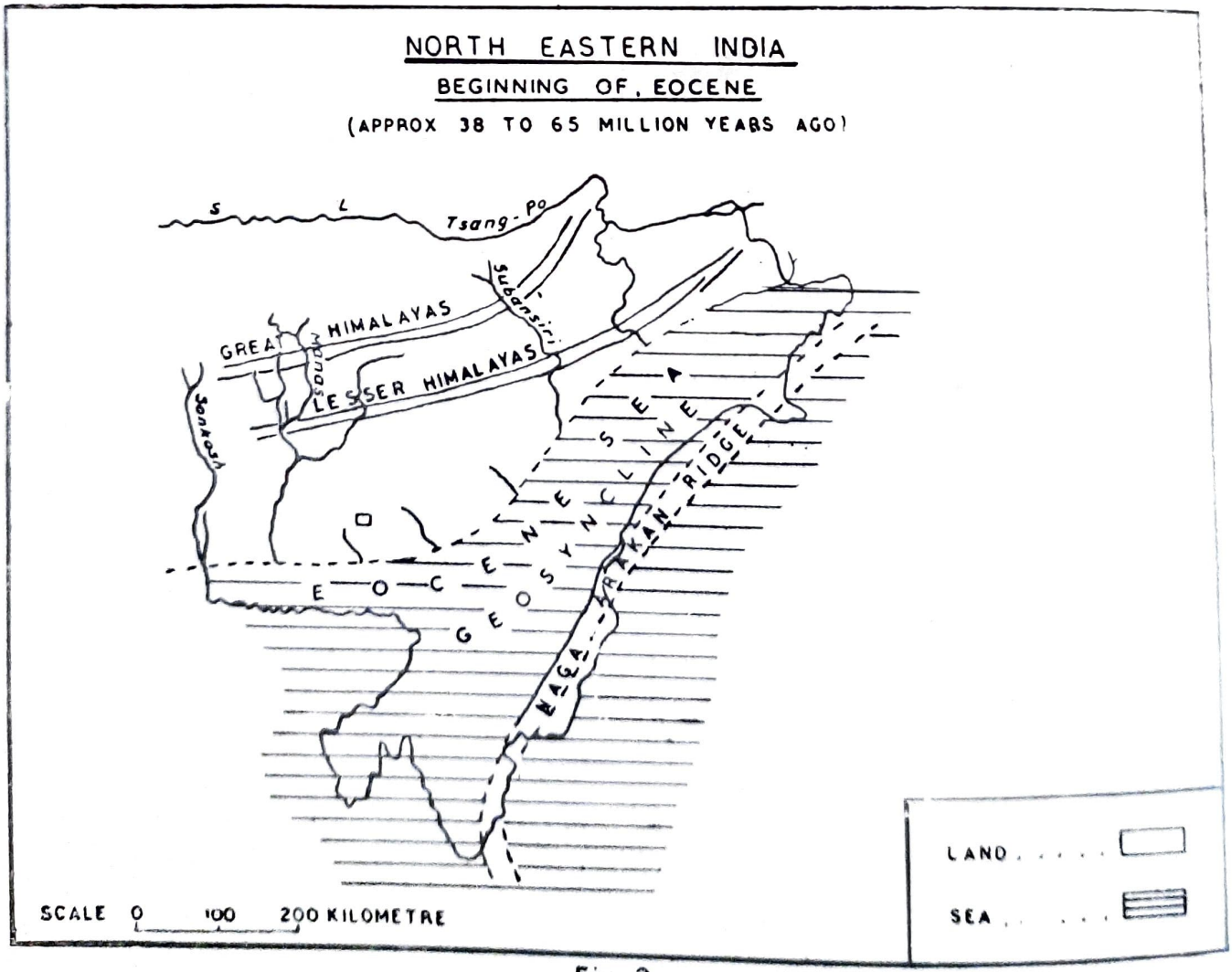

Fig. 2

The second phase of upheaval of the Himalayas took place in Upper Eocene (KRISHNAN, 1968) which has affected Assam only to a limited extent. There is no unconformity between the Jaintia Group and the Barail Group respectively of Eocene and Oligocene age.

OLIGOCENE

In the north the Great Himalayas and the Lesser Himalayas were being ridged up across the course of the antecedent rivers which continued to deepen their valleys while the uplift was in progress. In maintaining the gradient of their channels from the source behind the rising mountain to the plains, these rivers constantly got rejuvinated, carried heavy burdens of sediments to the sea in the south.

In response to the Upper Eocene phase of the Himalayan uplift, there was in the south-east another spurt in the upheaval of the Naga-Arakan Yoma ranges. On the unstable edge of the shelf a foreland trough developed, where a marginal marine type of sediments accumulated and sedimentation was tectonically controlled.

Thus in the Oligocene there were three basins of varying sediments. They were the shelf, the foreland deep and the geosyncline with varying total thickness of sediments. In upper Assam, the average total thickness on the shelf was 1,200 m., in the foreland deep 6,100 m., and in the geosyncline of Surma Valley the thickness averaged 5,500 m. It is thus seen that the maximum thickness of sediments with swamp build-up had been reached in the rapidly subsiding unstable part of shelf. Most of this mass of sediments was trans-

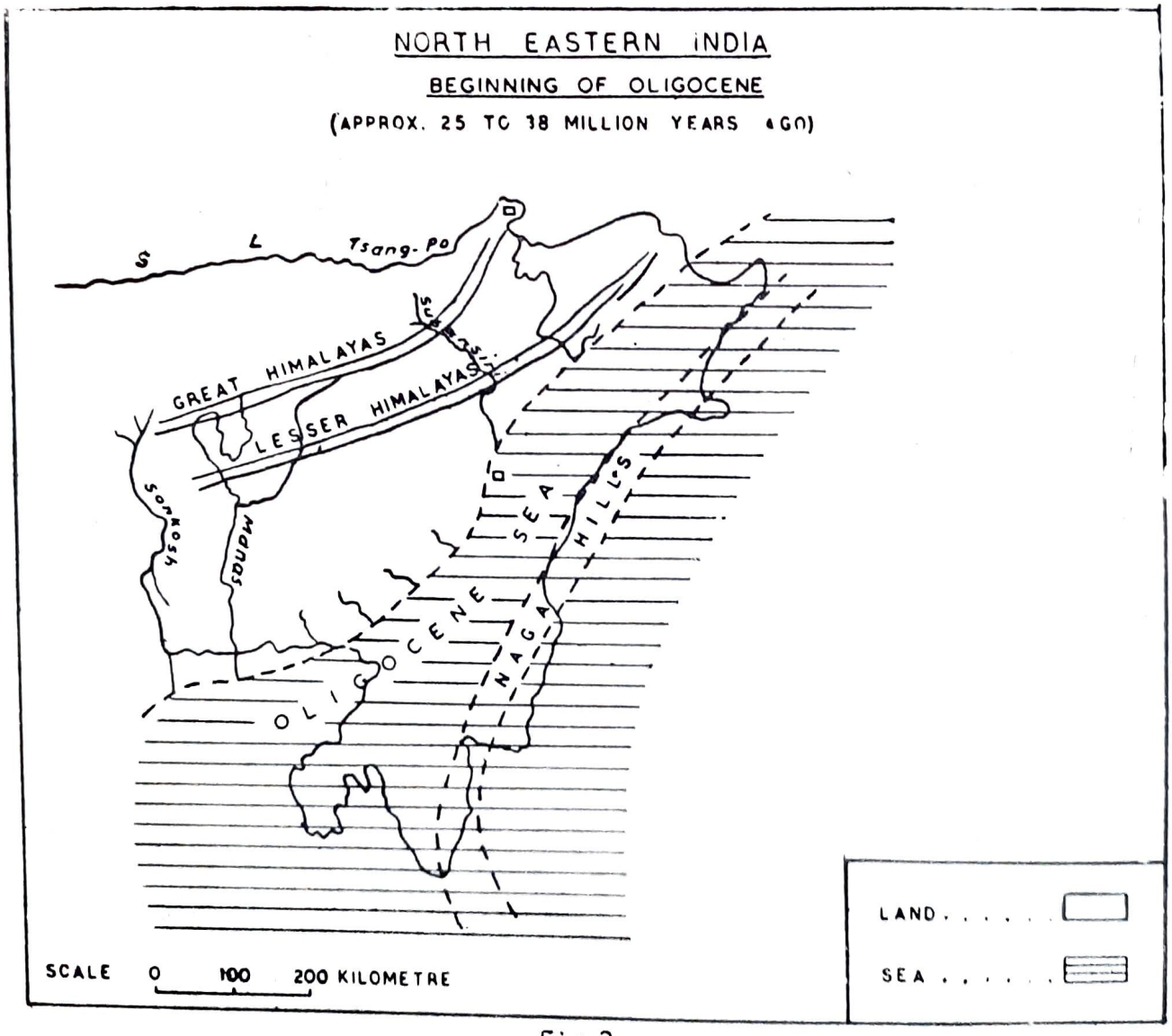

Fig. 3

ported by the antecedent rivers from the rising Himalayas. Figure 3 roughly represents the geography of the period.

At the end of the Oligocene an important event took place; the whole of Assam was affected by a gentle differential movement which resulted in a general centripetal tilt. The Shillong Plateau and the Mikir Hills were tilted up to higher level than the rest of the country for they remained as high ground with pronounced local relief after the rest of the country had been reduced to flatness. The sea receded to the south to the region of Arakan. Deposition gave place to erosion. Lengthening their courses, the antecedent Brahmaputra, Subansiri, Manas and Sankosh, along with other consequent rivers brought their burdens of load to the sea on the south.

Miocene

In Figures 4 and 5 an attempt has been made to show the geographical conditions during early and late Miocene. Due to the river patterns mentioned above, the Miocene deposits became increasingly fluviatile when traced northwards. Further, during this period, the distinction between foreland and geosynclinal facies nearly disappeared. The Surma Group of Miocene age are divided into two formations: the lower formation is called the Bhuban while the upper one is known as the Bokabil. The Bhubans are comparatively thin in Upper Assam, sometimes even absent and the Bokabils entirely

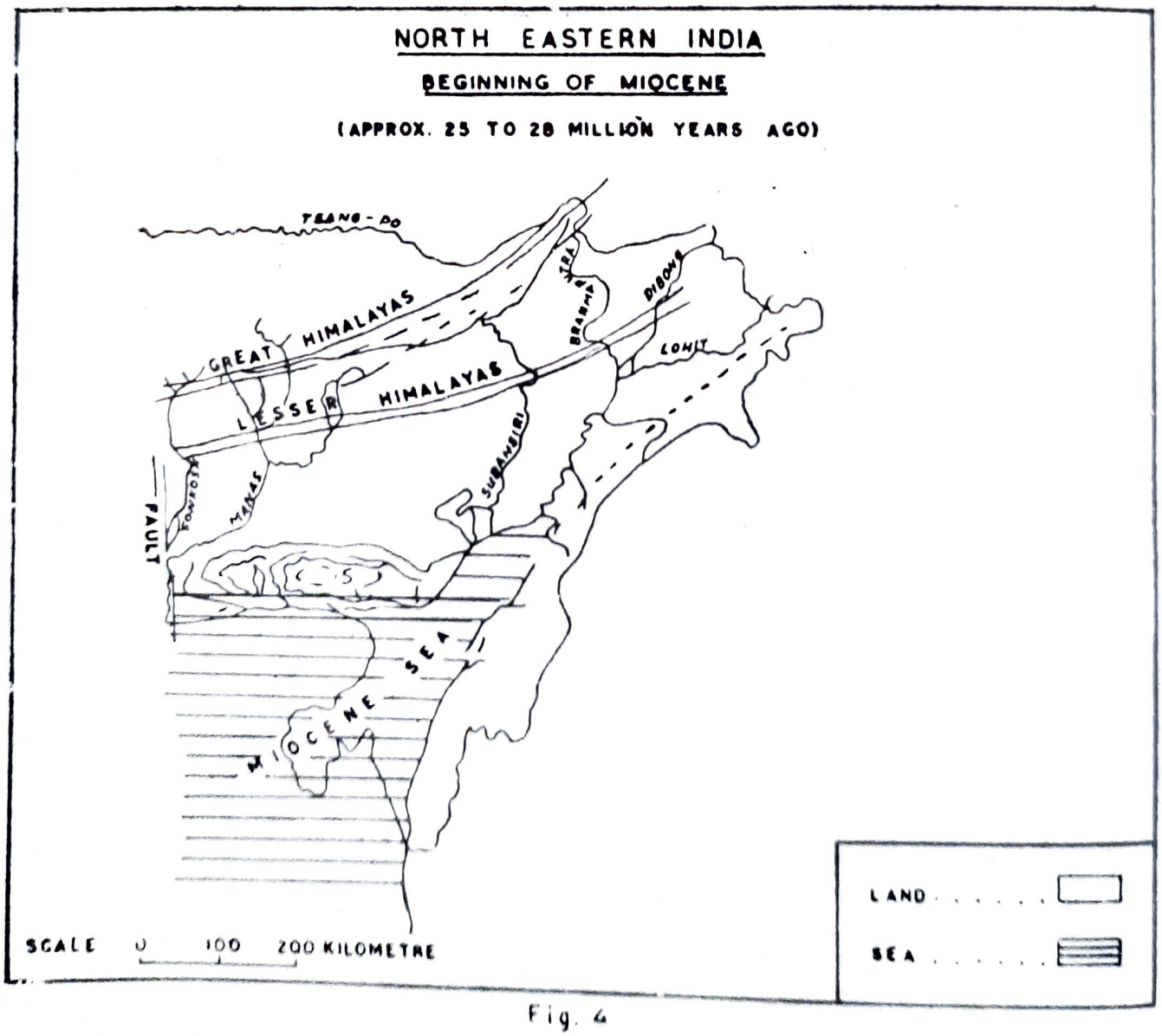

Fig. 4

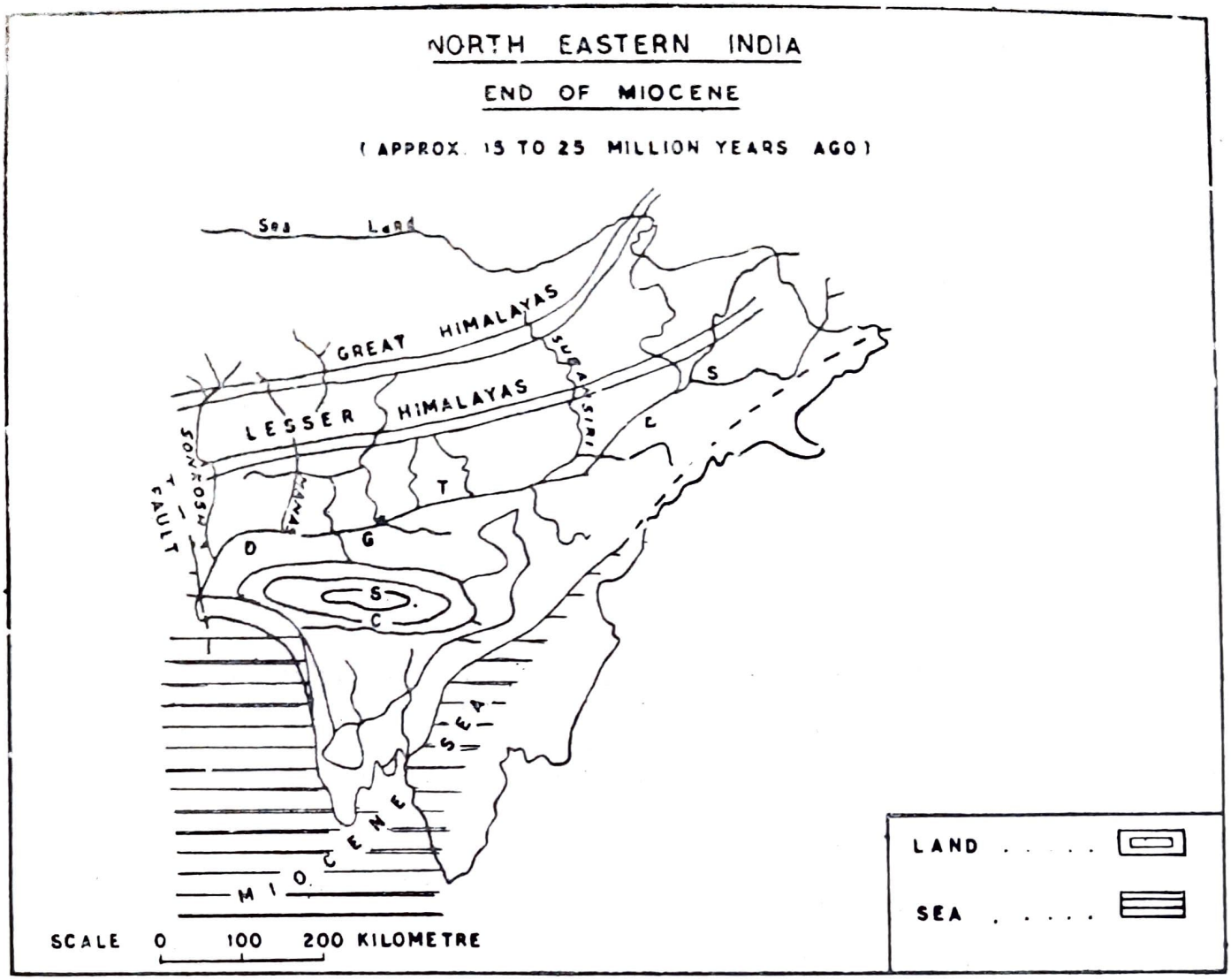

Fig. 5

lacking. The Naga Hills Miocene is fluviatile in origin as it contains fresh water mollusc, *Batissa*. The Bhubans are seen south of the Shillong Plateau only near the Dawki Fault but continue in Bangladesh. On the southern edge of the Garo Hills, the Bokabils appear overlapping the Kopilis (Upper Eocene).

In the Middle Miocene, the third and the most powerful movement in the upheaval of the Himalayas took place and foredeep was formed in front of the Himalayas to which the Brahmaputra resorted changing her old course. The Subansiri, the Manas and the Sankosh now joined her as tributaries along with many consequent rivers from the north and south.

One of the most outstanding discoveries of fossils in recent years has been that at Teliamura and Narengbari in Tripura, where an assemblage of mammalian, reptilian and piscine remains have been found in conglomeratic beds belonging to the Bokabil Formation. (Trivedi, 1966). The mammalian fossils have been assigned to a Tortonian age (Krishnan, 1968). The depositional environment is distinctly estuarine. An occurrence of mammalian fossils along with Bokabil marine forms was reported by Scot from the neighbourhood of Mahandraganj in Garo Hills in the early part of the last century. Unfortunately, the occurrence has not been rediscovered since, but there is sufficient evidence to show that the Bokabil become estuarine towards the top over a large area. The sea was receding to south and ultimately reached its present position.

The significance of the fossil discovery in the Bokabils is that it strongly suggests a

Pliocene age to the overlying Tipam Group which was hitherto regarded as Miocene. The Tipams were mostly fluviatile in Upper Assam, in the Himalayan foot hills and for a greater part in the Surma Valley except in the far south. In the Brahmaputra Valley some swamps persisted where the accumulated vegetable remains gave rise to lignites.

The Dihings are entirely fluviatile and may have been derived from the rising mountain ranges to the north-east to east. They are in the nature of a fanglomerate and are of Pleistocene age.

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