JOURNAL OF THE PALAEONTOLOGIAL SOCIETY OF INDIA
VOLS. 23 & 24, 1980 pp. 23. (*For* 1978-79).

# *PONDAUNGIA* (PRIMATES, NOTHARCTINAE?) NEEDS RESTUDY

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ABSTRACT

The Asian late Eocene primate *Pondaungia cotteri* possesses pseudohypocones on $M^{1-2}$. Because such peculiar cusps are found among the Order Primates only in genera of the widespread Eocene Subfamily Notharctinae, *Pondaungia* is probably a member of that group. This genus needs restudy, however, to confirm or reject this preliminary hypothesis.

G. E. Pilgrim (1927) described a primate, *Pondaungia cotteri*, from the upper Eocene Pondaung Formation of Burma. Since 1927, there have been four theories on the classification of *Pondaungia:* (1) it is an early pongid (Colbert, 1937, 1938); (2) a forerunner of the Anthropoidea (Clark, 1959, Conroy and Bown, 1974); (3) a questionable hominoid (Simons, 1965); and (4) it is a condylarth (von Koenigswald, 1965). The holotype of *P. cotteri* is G.S.I. (Geological Survey of India, Calcutta) D 201, 202, and 203, a left maxillary fragment with $M^{1-2}$ and partial horizontal rami of the mandible, the left ramus with $M_{2-3}$, and the right ramus with $M_3$. The principle reasons there are four theories on the classification of *Pondaungia* are that most workers who have discussed the genus either have (1) not studied the holotype of *P. cotteri*, or (2) not studied a cast of the holotype, or (3) not even read Pilgrim's description. Pilgrim (1927, p. 14) observed that $M^{1-2}$ in *P. cotteri* possess peculiar cusps, pseudohypocones, which I have observed also for a cast of the holotype kindly provided by Dr. V. M. Shastry, Director of the Geological Survey of India. Pseudohypocones are rear inner cusps that originate by fission from the front inner cusps, the protocones (Gazin, 1958). Such peculiar cusps are found among the Order Primates only in genera of the Notharctinae, a subfamily known from the Eocene of Europe and North America (Russell, Louis and Savage, 1967) that probably originated in Africa during the Paleocene (Madden, 1969 observation). It is of interest that the Hominoidea, like nearly all non-notharctine primates with rear inner molar cusps, do not possess pseudohypocones but instead possess hypocones that originate from the rear cingula. The possession of pseudohypocones, therefore, would appear to preclude *Pondaungia* from being a member of the Pongidae or even a questionable member of the Hominoidea.

Paleozoogeography also would appear to preclude *Pondaungia* from being a pongid or questionable hominoid. This genus is a representative of the highly endemic, early Tertiary mammalian fauna of Asia—which was a continent distinct from other Old World continents during the late Eocene (see Borissiak, 1962). The earliest undoubted Hominoidea—*Oligopithecus*, *Propliopithecus*, *Aegyptopithecus*, and *Aeolopithecus*—first appear in the fossil record in Africa during the Oligocene (see Simons, 1972) and this group initially differentiated (see Simons, 1965), and thus probably originated, in that continent.

In my view *Pondaungia* is probably a member of the Notharctinae. I have thus provisionally, though questionably, placed the genus in that subfamily in the title of this note. However, my view is based solely upon one of Pilgrim's observations made more than fifty years ago, an observation with which I concur, judging from a cast. Clearly *Pondaungia* needs restudy to confirm or reject my preliminary hypothesis of its affinities.

ACKNOWLEDGEMENTS

I thank Dr. V. M. Shastry for providing a cast of the holotype of *Pondaungia cotteri* for study and Dr. G. C. Conroy (1978) for mentioning a 1975 version of this note.

REFERENCES

BORISSIAK, A. A. 1962. A survey of fossil sites of Tertiary land mammals in the U.S.S.R. *Int. Geol. Rev.* **4** : 845-867.

CLARK LEGROS, W. E. 1959. *The Antecedents of Man.* Edinburgh University Press, Edinburgh.

COLBERT, E. H. 1937. A new primate from the uper Eocene Pondaung Formation of Burma. *Amer. Mus. Novit.* **951** : 1-18.

COLBERT, E. H. 1938. Fossil mammals from Burma in the American Museum of Natural History. *Amer. Mus. Nat. Hist. Bull.* **74** (6) : 255-434.

CONROY, G. C. 1978. Candidates for anthropoid ancestry : some morphological and palaeozoogeographical considerations. In Chivers, D. J. and Joyssey, K. N. *Recent Advances in Primatology* **3**: 27-41. Academic Press, New York..

CONROY, G. C. AND BOWN, T. M. 1974. Anthropoid origins and differntiation: the Asian question. *Yrbk. Phys. Anthrop.* **18** : 1-6.

GAZIN, C. L. 1958. A review of the middle and upper Eocene primates of North America. *Smithson. Misc. Coll.* **136** (1) : 1-112.

KOENIGSWALD VON, G. H. R. 1965. Critical observations upon the so-called higher primates from the upper Eocene of Burma. *Kon. Neder. Akad. Wetensch* (B). **68** : 165-167.

PILGRIM, G. E. 1927. A *Sivapithecus* palate and other primate fossils from India. *Palaeont. Ind.* **14** : 1-27.

RUSSELL, D. E., LOUIS, P. AND SAVAGE, D. E. 1967. Primates of the French early Eocene. *California Univ. Publ. Geol. Sci.* **71** : 3-31.

SIMONS, E. L. 1965. New fossils apes from Egypt and the initial differentiation of the Hominoidea. *Nature.* **205** : 135-139.

SIMONS, E. L. 1972. *Primate Evolution an introduction to man's place in nature.* Macmillan Co., New York.

JOURNAL OF THE PALEONTOLOGICAL SOCIETY OF INDIA
VOLS. 23 & 24, 1980 pp. 24—29. (*For* 1978-79).

# THE GEOMORPHIC HISTORY OF BRAHMAPUTRA

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ABSTRACT

The Brahmaputra is an antecedent river of many names which came into existence when the Himalayan Tethys dried up about early Eocene. It collected snow and water falling upon the Nepal and Assam sections and changing its course from east of what is now Namcha Barwa to the south discharged into the Assam gulf. The vast load of sediments brought down from Tibet built the huge delta of sandstone, shale and coal alternations in Upper Assam. During the yearly part of the Tertiary other south-flowing antecedent rivers such as the Subansiri, the Manas, the Sonkosh, also built deltas at their mouths, the eastern ones of which coalesced. When in Middle Miocene a foredeep was formed in front of the uplifting Himalayas, the Brahmaputra quietly usurped it and flowed westward thereby changing the former pattern of drainage. Because the valley of the Brahmaputra is not of its own making, the landforms now seen are not a development of a river displays.

## INTRODUCTION

The Brahmaputra is known as the Tsang-po in Tibet. The Tsang-po rises in the Chemayung glacier at Tamchok Khambad Chorten near the sources of the Karnali and the Sutlej rivers. From its source in south eastern Tibet to its mouth in the Bay of Bengal the total length of its course is 2,900 km. or slightly less than that of the Indus. It has a drainage area of about 940,000 sq. km.

The course of the river up to the commencement of the delta opposite the southwest corner of the Garo Hills district can be divided into three main sections, namely (1) the Tibetan section, (2) the Himalayan section and (3) the Assam-Bangladesh Plain section. Each section has its distinguishing features, a distinctive name and a colourful history. From where the Tista joined it on its right bank around the year 1787 till its junction with the Ganga, it is known as the Jamuna (Pascoe 1964).

## 1. THE TIBETAN SECTION

In the Tibetan section, commencing its course at a height of 5000 m., the Tsang-po flows over a dry and flat region that has not been deeply cut into as has been the case with the Indus and the Sutlej. In fact, it is quite a sluggish river south of Lhasa. The elevation of its bed is 4523 m. at Tradom, 3608 m. at Shigatse and 2440 m. at Gyala Saridong near Namcha Barwa at the easternmost point of the section. The length of this section from its source to the easternmost point, Namcha Barwa, is 1,600 km. Between Shigatse and Namcha Barwa the Tsang-po has a grade of 1.6 metre per Kilometre.

The right bank tributaries to the river in this section are derived from a low range between the Himalayas and the Tsang-po and the left bank ones from the Nyen-Chin-Tanghla range to the north. The width of the basin is roughly about 400 km. The river flows through the centre of the valley. We may almost call this the "Valley Tract of the river".

It will be observed that here the Tsang-po flows parallel to the main Himalayan range in a north-east direction over a wide bed which, however, rapidly narrows down to a hundred metres as it reaches Namcha Barwa (7755 m.)

Over the Tibetan section the river flows in a basin made up of sediments of the Tethys-Himalayan zone with which is associated the ophiolitic (ultramafic) zone observed in the Upper Cretaceous flysch along the northern border of the Kashmir syntaxis. Gansser (1964) believes this ophiolitic zone continues up to Namcha Barwa. The most remarkable feature of the river in this section is the straightness of its course, suggetsive of some tectonic line. By magnetometric traverses, Weinert had shown as early as in 1938 that the Tsang-po here follows a major tectonic disturbance zone.

## 2. THE HIMALAYAN SECTION

The Himalayan section starts east of Namcha Barwa near Timpu and ends with its entry into the Assam plain near Sadiya. In this section it is no longer the Tsang-po but the Dihang, which goes round the peak of Namcha Barwa (7755 m.) and to the south and west of Gyala Peri (7150 m). Since the elevation of its bed is only 2440 m., the valley sides to the west rise in sheer cliffs some 5300 m. high. West of Gyala Peri, it is joined by a tributary called the Yigrong. It then turns sharply south, cuts across the mighty Himalayan ranges and reaches the Assam plain near Sadiya over a series of precipitious cataracts and falls.

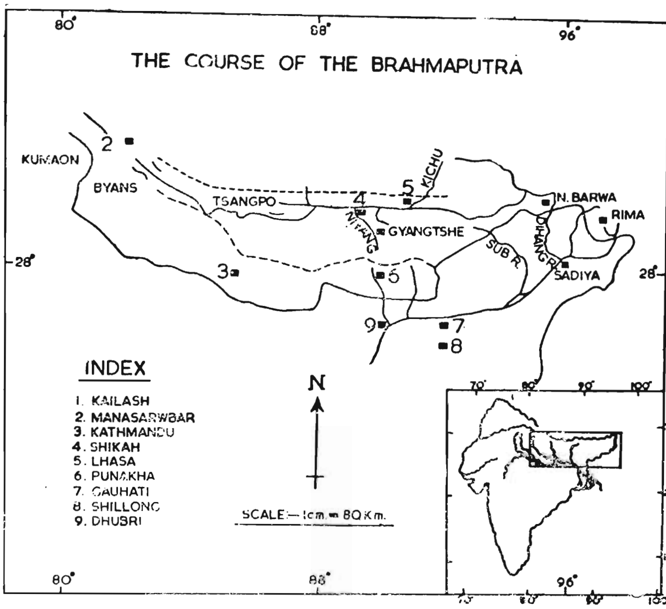


Fig. 1. The course of the Brahmaputra

Over this section, the Dihang advances in a screw like course swinging from side to side through overlapping steep scarps till it reaches the plain. In other words, the river flows through a zig zag gorge, unlike the Indus which emerges from the main Himalayas in a comparatively broad valley. The Yigrong is the only tributary of note. At its entrance into Assam, the elevation of the bed of the Dihang at Sadiya is only 135 m. In a length of about 340 km. in this section, the river drops through a height of 2,300 m.

The river here crosses the main Himalayan range. The geology of this section is not fully known. Only information is available through occasional traverses and broadly the picture would appear to be as follows :

First the Dihang passes over a zone of Tethys Succession then through the Central Himalayan granite zone, followed by a zone composed of the Dalings with their granitized equivalents, the Darjeeling gneisses. The Dalings are slightly metamorphosed slates and thick argillites. The metamorphism increases north-wards. This zone is separated from the central granitic zone by a thrust plane. To the south of the Daling-Darjeeling zone are the Lower Gondwanas with which are associated Permo-Carboniferous marine facies, exposed in the Ranganadi river valley section and of fossiliferous Permian Triassic rocks north of the Lohit depression. Westward in Bhutan the coal-bearing lower Gondwanas form an anticlinal structure exposing reversed succession. The Lower Gondwanas are thrust over a narrow belt of Siwalik rocks. This is the main Boundary fault. Thus, in this section the Dihang crosses at least three thrust zones, yet it is surprising to find only a single tributary of significance.

From what has been said earlier, it would appear that the Himalayan section forms the 'torrent of mountain tract' in the normal development of an ordinary river and constitutes the youthful stage in the cycle of erosion. The torrent tract following the valley tract is an anomaly and calls for an explanation.

Fortunately, the cause is not far to seek. The gorges in the mountain tract have arisen paripassu with the upheaval of the Eastern Himalayas across the course of the river as the Brahmaputra is an antecedent river (Pascoe *l. c.*).

Why did the Tsang-po take a sudden turn to the south east of Namcha Barwa ? Let us have a look at the relief map of Tibet. Just where the Tsang-po normally should have continued further east we find that several ranges to the east and southeast rise above the plateau and swinging round towards the south from the almost impenetrable barrier of the Great Snow Mountains. The Tsang-po had necessarily to seek an outlet to the south because of this pre-existing barrier.

3. THE ASSAM—BANGLADESH PLAIN SECTION

At the mouth of the Assam Valley, the Dihang is no longer its former self ; it has a new appelation. It is now the Brahmaputra. From the east, the Dibong and the Lohit join it. The Dibong drains the Himalayas east of the Dihang while the Lohit drains an area between Assam and Burma. So the Brahmaputra is not the Lohit or the Red River of popular conception.

West of Sadiya the river flows in a more or less southwest direction up to Gauhati, then in an east-west direction up to Dhubri where it turns SSW for a short length before taking a southerly direction along the western border of the Garo Hills District of Meghalaya.

Within Assam, the main tributaries on the right bank are the Subansiri, the Bharali, the Manas and the Sankosh which last forms the inter-state boundary with Bangladesh. On the left bank are the Sisi, the Dibang, the Lohit, the Noa-Dihing, the Disang, the Dikhaw, the Dhansiri, the Kolong-Kopili and the Krishnai.

About the Subansiri very little is known except that it rises north of the main Himalayan ranges and has tributaries both from the north and south of the ranges. It runs for a length of 160 km. in the plains before joining the Brahmaputra at the western end of Lakhimpur District.

The Manas rises in the north-western slope of Kula Kangri peak and breaks through the main Himalayan ranges at Thunkar south of Lhakhong Dzong. The bed of the river at this gorge is at an altitude of 3,000 m. and is impassable.

The Sankosh drains the area between the Kula Kangri peak and the Chomo Lhari peak. It flows by Punakha where it is 365 m. wide but narrows down

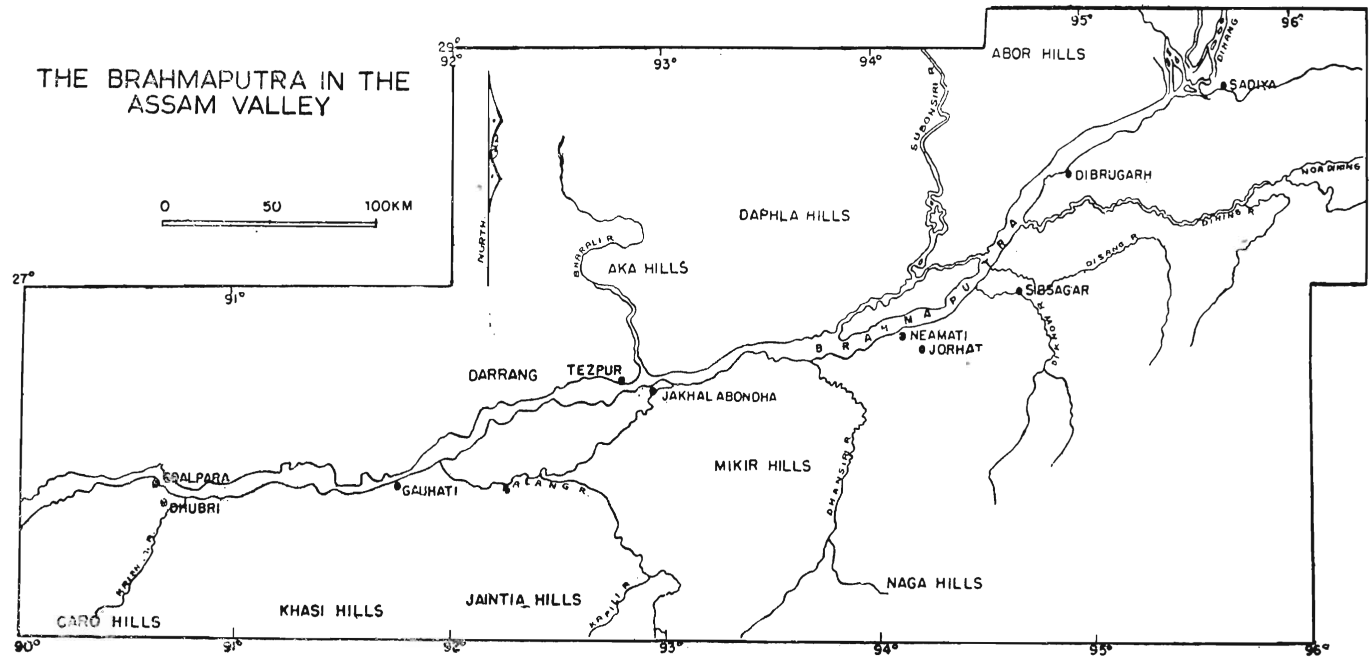


Fig. 2. The course of the Brahmaputra in the plains of the Brahmaputra valley and her tributaries.

further south to flow through a gorge. It joins the Brahmaputra at Patamari below Dhubri.

The rest of the tributaries on the right bank rise in the Lesser Himalayan zone. The Assam Himalayas, however, rise very abruptly from the plain and the foothills region is narrow and the sub-Himalayas are comparatively low in altitude than in other parts. Of the tributaries on the left bank, the Noa-Dihing rises near Chaukan pass at the extreme northeast corner of Assam on the Assam-Burma border. The Disang and the Dikhaw both rise in the Naga Hills, the Dhansiri in the Barail ranges, having a very longish course of 290 km. while the Kopili rises from the western extremity of the Barail ranges. The Krishnai rises in the Assam Plateau and after a course of about 100 km. joins the Brahmaputra.

From the very entry of the river into Assam, the valley opens out very wide. Near Dibrugarh, it is roughly about 160 km. wide, at Gauhati about 208 km. and at Goalpara 274 km. The gradient of the river varies in different portions of this section. In the Dibrugarh-Tezpur portion it is 12 cm/km ; in the Tezpur-Gauhati portion 8 cm/km ; in the Gauhati-Dhubri portion 9 cm/km. The width of the channel also varies ; at Dibrugarh it is 1874 m. wide at Tezpur 1201 m., at Gauhati 1116 m. and at Goalpara 1364 m.

In Assam, the Brahmaputra generally courses over an alluvial plain but from Tezpur westward, portions of the basement, Pre-Cambrian rocks, peep out from below the alluvial cover and in some stretches of the river themselves form banks. The alluvial plain itself varies in width in different portions. On a rough estimate near, Dibrugarh and Jorhat the plain is about 50 km wide, near Tezpur about 33 km. near Gauhati and Goalpara about 32 km. wide.

Throughout its course within Assam the river after floods is braided ; bars of sand and silt are left in the channel floor and the main current changes its course from time to time, which makes navigation in the dry season fraught with danger requiring depth plumbing as the steamer advances. Prior to the earthquake of 1950 (Paddar 1952) the river was navigable up to the extreme end of the Assam Valley at Dibrugarh. It is no longer so ; steamers now can ply only up to Neamati. When the river is in flood the meandering current erodes the soft banks. No levees are known to have formed on the bank when the flood subsides. In recent years after the earthquake of 1950, the river bed appears to have been raised and as a consequence during floods vast riverine tracts are inundated with devastating results ; so artificial levees or embankments have been built. One of the beneful effect of these embankments has been that the river is beginning to silt up the confined channel with materials that would otherwise have been spread out as alluvium over the plain. The most conspicuous example of artificial levees is seen in the Mississippi valley (Holmes, 1944). Little more than a century ago floods along the Mississippi and its tributaries were easily controlled by levees about four feet high. The levees have since had to be raised several times. By 1927 they were three or four time as high but nevertheless a great flood then broke through and devstated 25,000 sq. miles. Stronger levees up to 6 to 9 m. high have now been built. The U. S. consultants to our problem gave similar advice, as our experience with embankments has not been satisfactory.

There is one big island in the channel of the Brahmaputra, north of Jorhat, called the Majuli island. Significantly enough this island is situated at the point where the Subansiri joins the river. Floods in recent years have eroded away a large part of its area.

Thus in the Assam section, the river appears to have reached the stage of full maturity although the landforms developed belie such a belief. This is because the valley is not of its own making.

Let us now enquire into the geological composition and structure of the river basin. West of Tezpur, as we have already seen, the basin is made up of Pre-Cambrian rock beneath a veneer of alluvium. East of Tezpur it is made of Tertiary rocks laid over a Pre-Cambrian basement. We know that the Ganga-Brahmaputra basin forms a continuous strip along the southern border of the Himalayas. The eroded and rather irregular surface of the northern edge of the Peninsular Shield underlies the Ganga Basin and the Himalayan border and dip to the north at a low angle of one to three degrees (Krishnan 1968). No borehole has been put down north of the Brahmaputra or near the Himalayan border here. The nearest borehole was at Raxaul near the Nepal border (Krishnan *l.c.*) which passed through the Pre-Tertiary Unconformity at 4,150 m. Thus the Siwaliks are thinner here than further west. The 450 m. of Pre-Tertiary rocks penetrated resemble the Krol Formation. A bore hole at Muzaffarpur about 140 Km. directly south of the above passed through the Pre-Tertiary unconformity at 1700 m (Krishnan *l.c.*) Aeromagnetic surveys carried over the Ganga Basin revealed no longitudinal faults. In Assam, the Pre-Cambrian basement is exposed from Tezpur west-ward. A bore hole put down at Disangmukh proved the basement at a depth of 3,800 m (Personal communication). The regional slope of the basement in the Darrang district of Assam is to the north at an angle of more than three degrees ; north of the Kalang river the basement slopes regularly north at an angle of four degrees. At Jakhalabandha the basement is at a depth of 450 m.; at Tezpur at a depth of 1,000 m ; at Gauhati at 340 m.; and at Dhubri at 30 m.

Immediately after traversing Assam the course of the Brahmaputra is determined by a fault zone trending north—south along the border of the Garo Hills district, which appears to continue up to the Himalayan foothill region near Torsa valley.

The source of the river lies behind the main Himalayan Range but the river has succeeded in maintaining the slope of its channel to the plains of Assam. This proves that the river was in existence before the Himalayas rose across its course and has been deeply cut into. In other words, the Brahmaputra is an antecedent river. The edge of the Tibetan plateau rose to form a watershed which coincides closely with the modern Ladakh or 'Northern' range and has existed since early Tertiary times.

The initial course of the river in Tibet, as has already been pointed out, was determined by a tectonic disturbance zone and the hair-pin bend at the eastern end by the presence of a pre-existing mountain range.

We may now start the geological history with the question ; when did the Tsang-po come into existence? The region in Tibet in which the Tsang-po rises was under waters of the Tethys up to Upper Cretaceous, more than 65 million years ago, when the first of the series of stupendous movements by which the Himalayas were uplifted to the present height took place. The result of this initial movement was to furrow the Tethys bed into a series of ridges and basins running longitudinally. Soon after, possibly in ealry Eocene time, the Tsang-po come into existence when the Tethys was completely wiped out and the sea bed became land, which incidentally made India at last an integral part of Asia. No glaciers were there then and the Tasng-po rose as an ordinary river.

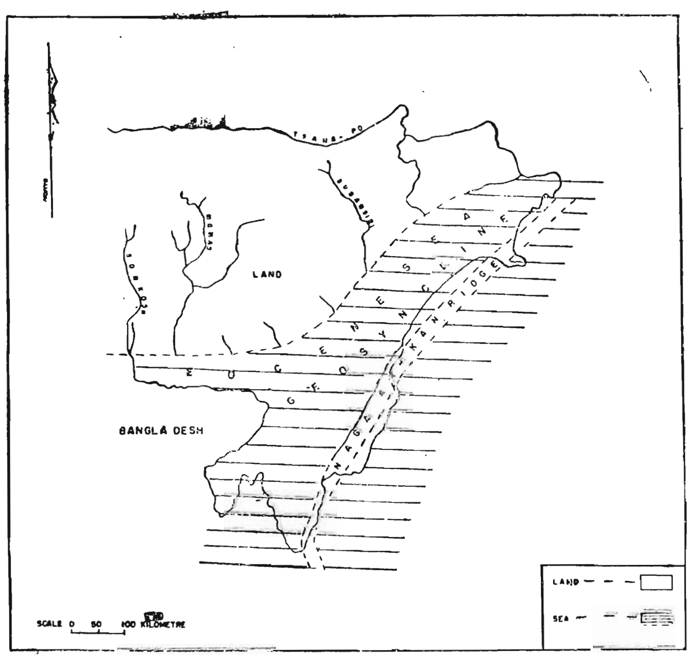


Fig. 3. Existence of Tsang-Po during early Eocene time (After Dutta. 1976).

Maclaren (1904) points 'to the probability that the drainage of all Tibet then, as now, tended to converge to a point at the head of the Assam valley ! Today in the more easterly portion of the Himalayas all the snow or water falling upon Nepal and Assam section finds its way ultimately into the Brahmaputra and some south-flowing antecedent tributaries of the Brahmaputra.

The eastern boundary of the anicent valley ran due south from the Miju Ranges along the flanks of the Burmese crystallines and metamorphics to nearly as far as Rangoon (Maclaren *l. c.*).

The Brahmaputra discharged into the easterly major geosynclinoria covering the area between the Shillong Plateau and the Shan Plateau, which however became divided along the middle into two gulfs in Laramide time by a series of submerged islands, but communication between the heads of the two gulfs still continued. The lower part of the westerly of these twin gulfs appear to have been of a wide open nature covering the Ganga-Brahamputra delta area from Mayurbhanj to Garo and Khasi Hills (Pascoe *l. c.*).

From the sub-surface geology of Upper Assam it is now known that in Upper Cretaceous time the gulf extended slightly to the west of Nahorkhatiya but in Eocene it extended as far north as Tengakhat (27°25′30″ : 95°08′) if not further. This transgression of the Eocene sea is also discernible in the Shillong Plateau.

Although the next phase of the Himalayan uplift in Upper Eocene was not particularly noticeable in Assam, its effects on sedimentation were profound for the muds and clays which form the Coal Measures of Upper Assam. The silt-laden rivers of the north, the ancient representatives of the Subansiri, Tsangpo, Dihang and the Brahmaputra, were pouring in from the higher lands of what is now Tibet. The vast quantities of sediments totalling nearly 5900 m in thickness derived from the fresh elevated source areas, soon built up deltas at the mouths of the Brahmaputra and other antecedent rivers, which gradually coalesced. Deposited during the Oligocene, the lower sandstone unit of the Barail Group was laid down in brackish water environment on the delta front and contains abundant arenaceous forams such as *Trochomina*, *Millammina*, etc. The upper unit, coal-shale alternations, was deposited in brackish water, back-lagoon, swampy environment in a warm tropical climate and contains diagnostic polospores (Ray *et al.*, 1972).

The oil-bearing sands in the Barail Group were laid down in channels of the meandering rivers in the alluvial flood plains.

The geological history continued unchanged till the end of Oligocene, when the Shillong peneplain was uplifted. Lee (1967) describes the western part of Assam as "a great simple tilted block of basement with a peneplained surface rising as an untrouble monocline from the low level of the Brahmaputra Valley on the north to form the extensive Shillong Plateau with an average height of 5,000 ft."

This spurt in uplift in Assam seems to have come much in advance of the third and greatest Himalayan upheaval which took place in Middle Miocene and was due possibly to back eddy of the Patkai movement from the southeast. The upward movement was so great and extensive that the Barails every where were denuded to varying depths. The unconformity above the Oligocene sediments is very wide-spread and of long duration.

The Miocene found the sea far to the south in the region of Arakan to which the Brahmaputra and the Subansiri with their tributaries from the east and west discharged. One of the characteristic features of Miocene sedimentation is that the beds become increasingly fluviatile when traced northwards. Subsequently, the sea advanced as a linear furrow between Mizoram and the Arakan Yoma as far north as Silchar and trending west reached the foot of the Garo Hills. Detailed studies carried out in Mizoram recently show that the Bhuban sediments of Miocene were laid down in a shallow, paralic environment in a quickly subsiding linear furrow (Ganguly, 1974) while in Tripura land had already emerged. The mammalian fossiliferous conglomerates of Tortonian Age of the Bokabil Formation recently discovered at Teliamura and Narengbari in Tripura bear witness to this fact (Trivedi, 1966).

Now a question arises : when did the Brahmaputra take its present course ? The Himalayas were raised to their present height by a series of upheavals, the third of which in Middle Miocene was the most severe and which is responsible for the present major features of the Himalayas.

Simultaneously with this phase of uplift, a long narrow furrow began to be formed between the mountain and the Peninsular mass on the south and gradually grew in depth in the coming millions of years. This depression continued to shift slowly to the south. Into this furrow now flowed the Brahmaputra changing its old course. The deflection of the Brahmaputra, according to Maclren, (*l. c.*) from a southerly course to a westerly one along the base of the Himalayas had taken place with the initial uplift of the Patkais and the trend of the Assam valley was finally determined. With the Brahmaputra deflected west, a new drainage pattern evolved in upper Assam. The south-flowing independent rivers of long-standing such as the Subansiri, the Manas etc. now joined the Brahmaputra as tributaries and on the left bank the river received streams rising in the newly uplifted Patkai and Naga Hills. Many others joined from the uplifted Shillong peneplain. Thus came the end of marine sedimentation in Upper Assam.

Why the Brahmaputra took a sudden turn to the south on the western border of Assam, we have already discussed. We may now ask, when did this faulting took place. Geophysical surveys recently carried out provides the answer. It has been revealed that the Rajmahal and the Garo Hills are connected by a submerged basement ridge at a depth of 200 metres or less and that the basement slopes down from this ridge both to the north and south. Earlier, we have seen that the Shillong peneplain was raised at the end of the Oligocene. The same movement that gave the Assam Plateau its present shape at the end of the Oligocene, appears to have impressed on the ridge a similar shape as it formed a part of the Shillong peneplain. The faulting must therefore have taken place some time in the early part of Miocene prior to the formation of the long, narrow furrow to accommodate the Brahmaputra in its southerly course.

ACKNOWLEDGEMENT

I am grateful to Dr. S. N. Vishwanath, Oil India Ltd., and Shri S. K. Barooah, formerly Director, D. G. M., Assam for their various suggestions during the preparation of this paper.

REFERENCES

Dutta, S. K. 1976. Tertiary Palaeogeography of North-Eastern India. *Geophytology* **6** (1). India.

Ganguly, S. 1975. Tectonic evolution of the Mizo Hills. *Bull. G.M.M.S.* India. **47**.

Gansser, R. 1964. *Geolagy of the Himalayas*, Inter Science, London.

Holmes, A. 1944. *Principles of Physical Geology*, Nelson, London.

Krishnan, M. S. 1968. *Geology of India, Burma and Pakistan.* India.

Lee, G. M. 1967. Foreland Folding *Q.J.G.S.* **8**.

Maclaren, J. M. 1904. Geology of Upper Assam Record *G.S.I.* 31.

Paddar, M. C. 1952. Preliminary Report on the Assam Earthquake of 15th August, 1950 *Bull. G.S.I.*

Pascoe, E. H. 1973. *A manual of the Geology of India and Burma.* **3**.

Ray *et al.* 1972. Subsurface Stratigraphy of an area north east of Nazira Syncline, Upper Assam Valleys *Bull. G.M.M.S. India.*

Trivedi, A. N. 1966. A note on the finding of vertebrate fauna in the Surma Series of Tripura and its bearing on the stratigraphy of the area. *Curr. Sci. Ind.* **35** (3) Feb.

Weinert *In* Krishnan, M.S. 1968. *Geology of India, Burma and Pakistan.*