



Late Eocene to Early Oligocene Depositional System in Assam Shelf

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Introduction

Assam-Arakan basin represents a classical asymmetrical/ foreland basin flanked by NE- SW trending mobile Naga Schuppen belt on the East and Southeast and Arunachal Himalaya to the North and North- East. The present study purports to establish and understand the Late Eocene to Early Oligocene depositional systems of Barail Main Sand (BMS) in terms of the genetic stratigraphic sequence analysis of the region. Well log sequences and seismic stratigraphic analysis together with the biostratigraphic studies has been integrated to define various orders of depositional sequences, which are later mapped to bring out the regional depositional pattern. The study shows that the Barail Main Sand is relatively older in the northwestern part i.e in Disangmukh-Rudrasagar area and becomes progressively younger in the east and southeast i.e. Lakwa, Dimulgaon and Galeki area. Therefore, unlike the lithostratigraphy nomenclature, a prodelta to marine shale unit equivalent of BMS has been separated from the underlying Kopili unit, which helped bringing the depositional model more lucidly. A framework of deltaic progradational units, considered as a late High Stand to Shelf Margin System Tract representing a normal regression deposit, attributed to high sediment influx from West and Northwest were probably the favourable factors during the Late Eocene to Early Oligocene sedimentation in Assam Shelf.

Regional Geology: An Overview

Northeastern India represents the northern part of the Assam-Arakan basin, which extends westward beyond Bangladesh and West Bengal and also includes parts of Myanmar in the east and south (Fig. 1). Being bounded by eastern Himalayan fold belts on the north and Naga-Patkai fold belts on the east-southeast, it constitutes a vast intermontane basin. Most of its geological features are concealed by the Recent alluvial cover.

Tertiary rocks rest directly over the granite gneiss and is divisible into two Supergroups (Bhandari et al., 1973).

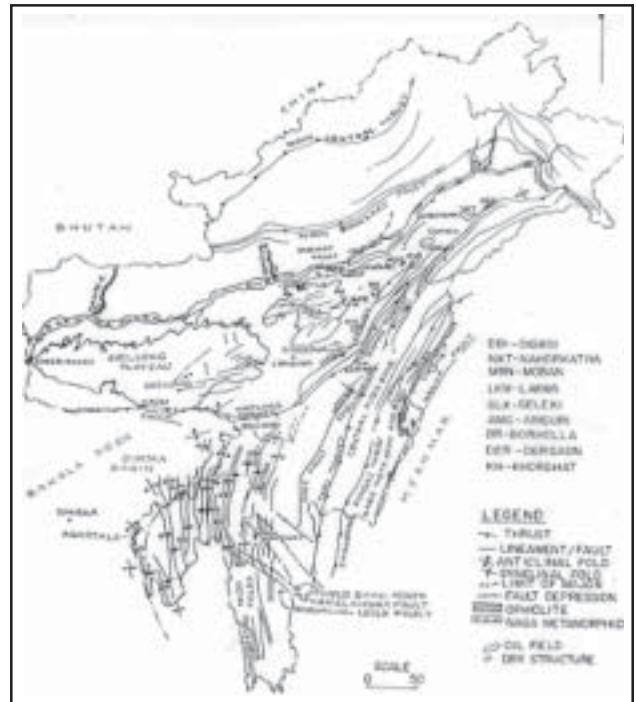


Fig. 1. Tectonic map of Assam- Arakan Basin. (After A. B. Dasgupta et. al., 2000)

The older Naga Supergroup of Paleogene age is further divided into Jaintia and Barail groups. These Paleogene sediments are mostly deposited in shallow marine to transitional environment. Thickness of these sediments increases from northwest to southeast suggesting the basal system towards southeast (Raju, 1968; Bhandari et al., 1973; Murty, 1983; Rao, 1983). The overlying Neogene sediments constitute the Brahmaputra Supergroup (Bhandari et al., 1973) was deposited extensively in fluvial environment except the initial shallow marine condition in Dhansiri and Surma Valley which was later replaced by brackish, deltaic and fluvial condition of deposition (Surma Formation).

Tectonic evolution of northeastern India is intricately linked with the movement of the Indian plate and its relationship with the tectono-chronology of the Himalayan Orogeny and is discussed in terms of the 'Oblique Collision and Tectonic Wedging Model' (Naik,

1994, 1997). Prior to collision and overriding, the northeastern India was almost certainly a passive margin and fronted by Mesozoic Oceanic lithosphere that was continuous with today's eastern coast passive margin. Subsequent to the Thrust loading, flexural sag i.e. the foreland basin was initiated latest by Late Eocene. In the Naga-Patkai Range the inner Thrust were emplaced at that time involving the Eocene and Oligocene sediments. South and East of Disang thrust, the Miocene and the younger series are not represented. The flexural process continued with landward migration towards NW in a classical Piggyback style.

Based on an integrated analysis of various geoscientific data, Naik (1997) proposed the allostratigraphy of the Paleogene sections of Upper Assam. Subsequently, using the sequence stratigraphic principles, the entire stratigraphic section of Assam has been divided into ten sequences (I-X) (Naik, et. al., 2001), within each sequence, some higher order sequences are also identified on well logs. The present paper deals with the study of the Seq-III covering broadly the Late Eocene-to Early Oligocene sedimentary unit in Assam Shelf. Stratigraphically it encompasses the well known Barail Main Sand (BMS) units and its equivalent shales in the basinal.

Methodology:

In the present work, well-log sequence and seismic stratigraphic analysis coupled with the biostratigraphic studies has been attempted and finally integrated following the standard sequence stratigraphic interpretation procedure (Vail & Warnardt, 1990). Various orders of depositional sequences have been defined and later mapped to bring out the regional depositional pattern. Though, on well-logs and also in biostratigraphic studies, cycles of higher orders (fourth even fifth order) are recognised, they are not well defined on seismic sections. Therefore, sequence boundaries, which are defined seismically and further calibrated using other co-lateral data, have been correlated regionally.

Multi-well studies using a suite of wire-line logs provide invaluable information to sequence analysis and help developing an architectural and space-time reconstruction of the formation. Besides defining the different system tracts, well logs are used for identifying the unconformity, which in turns defines the sequence boundary. Using all these criteria, sequence boundary SB-III has been defined in the present study on the top of a correlatable coarsening up unit and is considered as an

unconformity (Fig. 2).

Various System tracts identified on well logs following the criteria suggested by Vail et al. (1990) are used for regional correlation in a grid pattern. Micropaleontological studies and the established stratigraphic boundaries are also incorporated to make the informal correlation (rather matching) more formal and stratigraphically meaningful (Fig. 3).

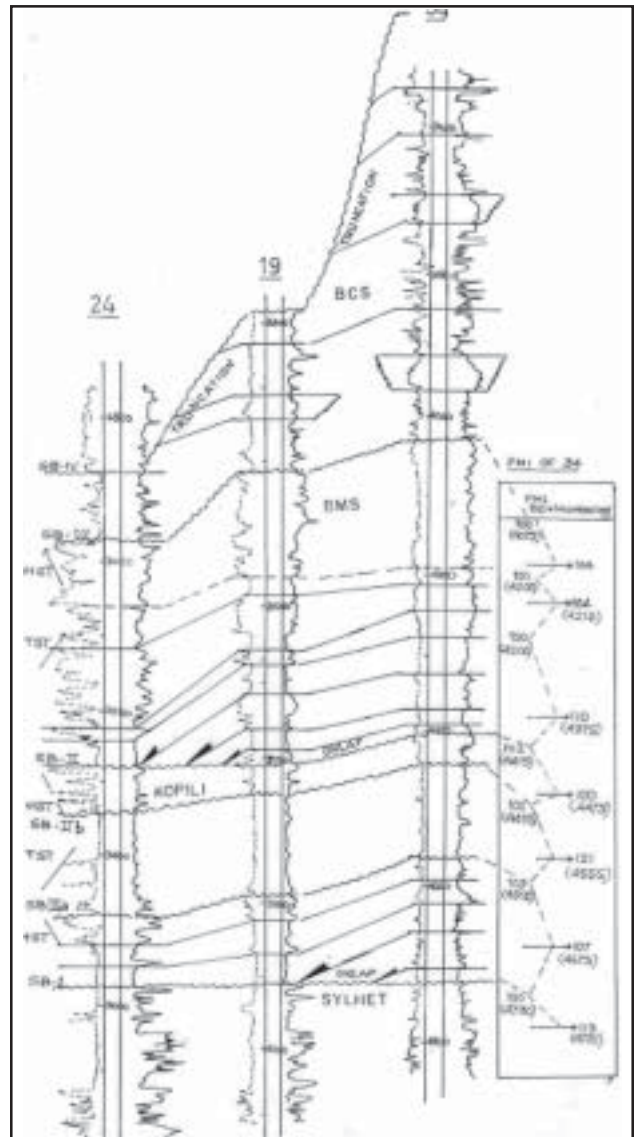


Fig. 2. Regional electrolog correlation showing various sequences and their associated system tracts, onlap, truncation on the top of SB- I and SB- III (datum- SEQ- I Sylhet).

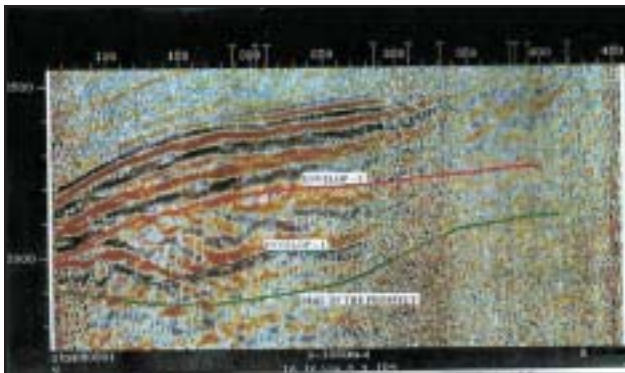


Fig. 3. Part of interpreted seismic section A- A' showing Progradational feature.

General Features of Seq-III:

Bounded unconformable below by underlying SB-II (Kopili) and above by coal– shale sequence of SB-IV, Seq- III representing a major part of Barail Main Sand (BMS) Formation. In the seismic sections, it is characterized mostly by low amplitude, moderate frequency to high frequency, discontinuous to patchy reflections.

Biofacies:

Microfauna within the Seqw. III sediments are relatively less in number. They are mostly arenaceous foraminifera with rare Rotalides and globular interminate oolites. The foraminifera include *Trochammina sp.*, *Haplophragmodes sp.*, *Miliammina sp.*, *Ammodiscus sp.*, *Ammorginalina sp.*, *Cyclammina sp.*, (Rao, 1983). Presence of thin but rich fauni zones are also known in this sequence (Mohan, 1973). The lower shale and silt unit is almost barren in nature and is included within the underlying Kopili Formation (Seq. II). Disappearance of calcareous foams, appearance of arenaceous sp. and the sharp decline in faunal population indicates an overall regressive phase during Seq. III sedimentation.

Electrofacies:

Within Seq-III, blocky, funnel and bell shaped, simple spike and tapered spikes are seen. The thick fining– up sandstones show ‘bell shape’ with sharp (erosional) bottom and gradational top contact. (Fig. 2). The overall funnel shape is often disrupted by superimposition of bell shapes facies resulting a composite amalgamated form of both the facies. Block shapes caused by homogenous sand fills or composite multistory are common. They depict

repeated cuts and fill within channel or minor fluctuation in channel location.

Seismic facies:

Within Seq. III, the seismic reflector corresponding to the thick and massive sand unit is discontinuous, irregular and patchy. The reflector loses its amplitude in some places and also sometimes terminates along a semicircular surface. These surfaces are interpreted as erosional channels (Fig. 3). Several base lapping mounded reflections, depicting individual mouth bars, have been inferred. Stacked lobes are often seen in stacked sections. On dip sections, hummocky clinofolds progradation patterns are also observed. The hummocky pattern of reflection and the sub-parallel, discontinuous natures of weaker events indicate interdeltic sedimentation (Mitchum et.al., 1977).

Sedimentation Model For Seq-iii: The Fluvio-Deltaic Model

Since the paleo-shelf break is not obvious in Assam region, it is logical to infer that the sediments deposited in the shallow marine to transitional set-up in this part may either represent transgressive or highstand or shelf margin system tracts formed landward to the depositional shelf break. Most of the earlier workers (Murty, 1983; Zutshi; 1985; Asthana and Dubey, 1986; Ahmed et.al., 1986, 1990, etc) suggest deltaic to fluvial environment of deposition of this sequence. Considering the wide scope and multifaceted nature of the work and the non- availability of chronological data for separating the individual deltaic cycles, an exhaustive microlevel analysis is not attempted. Only a board and brief treatment has been offered. Any depositional model for Seq. III has to account for the following characteristics;

- Association of lithofacies like sandstone, shale, silt and coal and their spatial variation.
- Presence of both coarsening up and fining up sequence.
- Poor faunal content with dominance of arenaceous foams.
- Presence of thin but rich fauni zones.
- Cyclic pattern of sedimentation with increasing number of cycles.
- Lobate configuration and blanket form of the lower units and bird-foot to elongated and crescent shapes with discontinuous sand bodies within the younger units.
- Low salinity of the formation water.

- Prograding pattern of sedimentation towards east and southeast.
- Characteristic electrofacies and seismic facies.

The Seq. III shows gradational base, coarsening and thickening- up deltaic deposit and sometimes capped by fining- up channel deposits. Broadly, it is composed of several smaller, asymmetrical shallowing- up sequences, each of which represents a discrete progradational event (Fig. 3). Following the convention of Vail et.al., 1977, these progradational units can be termed "fourth- order cycles". Prograding clinoform (Fig. 3) with top- lapes are seen on the upper part of the sequence. Base- lap is also seen in some sections against a continuous correlatable reflector within Seq. III. The sands within Seq. III look more continuous and are having high sand content. Isopach maps of these sands in different fields indicate broad lobate configurations (Fig. 4). Seq. III isochronopach map (Fig. 5) shows multiple depocentres in Rudrasagar, Charali, Geleki, Kuargoan, Mariani, Khoraghat- Uriumghat, Rajaphe- Chumukidema areas. The clastic input was mainly from W and NW direction (Fig. 4, 5). Though the broad pattern of the isopach map suggests a generalized lobate deltaic set up in the study area, development of barrier bar in the lower part could also be likely in basinal areas i.e. in

Amguri, Geleki, Lakwa etc. The different sedimentary facies, their electrolog and seismic signatures as mentioned above can very well be explained by a broad fluvio-deltaic environment prograding towards east and southeast. (Fig. 6).

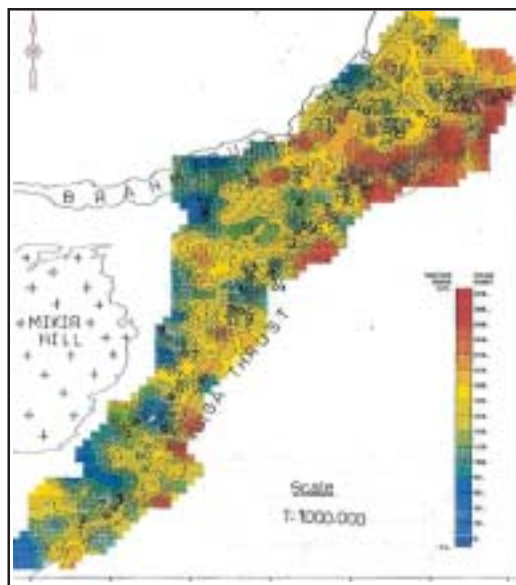


Fig. 5. Isochronopach map of SEQ- III (BMS).

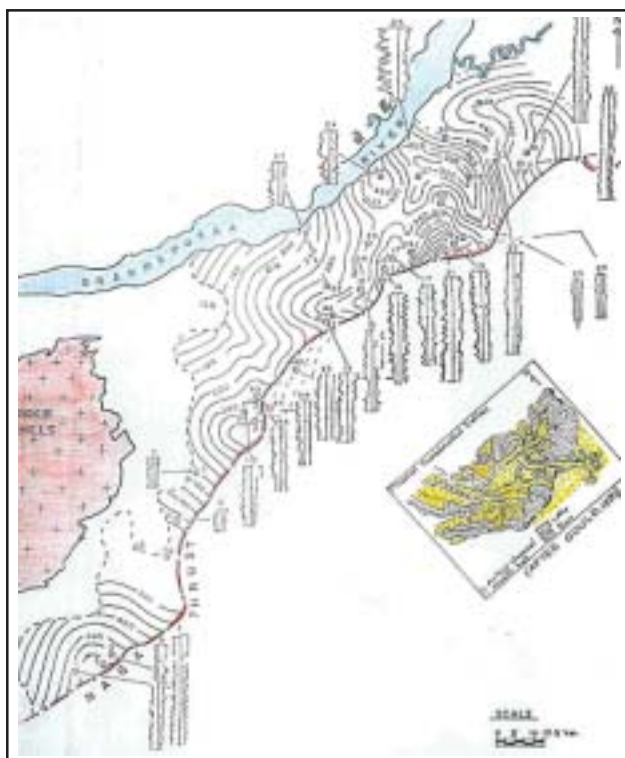


Fig. 4. Isopach map of SEQ- III (BMS).

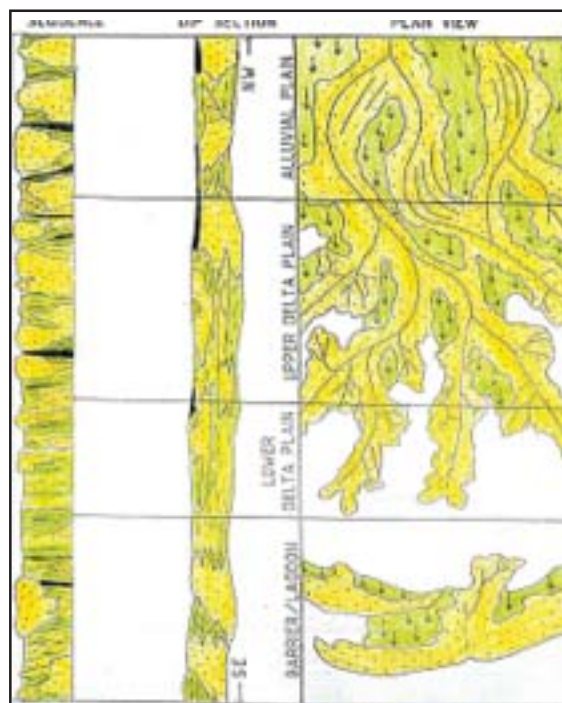


Fig. 6. Figure depicting depositional model for SEQ- III (Barail Main Sand).



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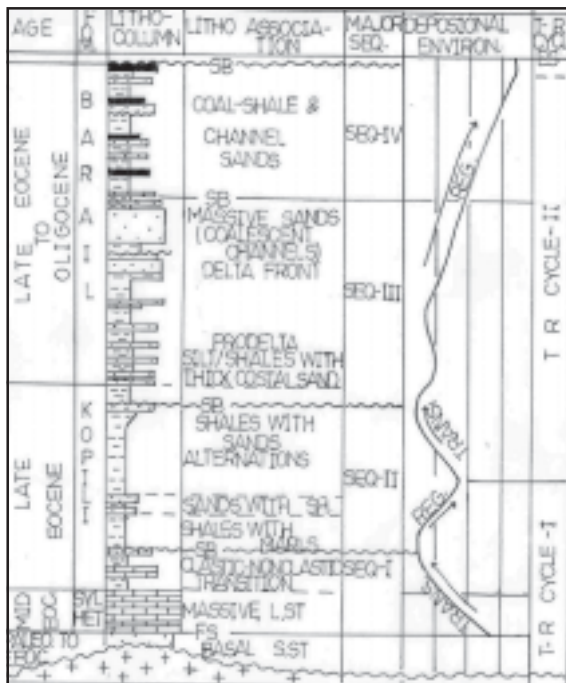


Fig. 7. Generalised lithostratigraphy, inferred relative sea level and sequence stratigraphic interpretation, SEQ- I to IV, Upper Assam.

The generalized depositional sequences and their associated system tracts in Assam have been depicted in Fig. 7. The model discussed above associates the lateral and vertical changes in the strata with the depositional setting that varied from an alluvium plain through upper and lower delta plains to a back- barrier marginal marine environment (Fig. 6, 8 & 9).

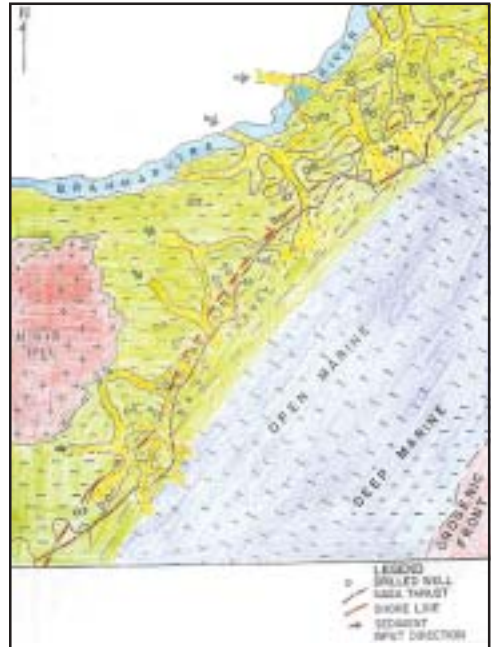


Fig. 8. Paleogeography during Late Eocene (SEQ- II, Kopili). (Not to the scale).



Fig. 9. Paleogeography during Lower Oligocene (SEQ- III, BMS). (Not to the scale).

Though the barrier and back-barrier facies of this model are little known in the study area, it is inferred that the initial sedimentation areas like Lakwa, Amguri etc. lying more towards the sea may represent these facies. This inference is based on the fact that the equivalent Barail sedimentation in Rudrasagar field has been interpreted as distributary mouth bars in the lower delta plain and the direction of progradation was towards southeast (Zutshi, 1985). Patil et.al. (1987), suggested a barrier bar-lagunal characteristically consists of orthoquartzitic barrier sandstones, tidal deltas and tidal channel deposits. The barrier sandstones are sometimes erosively based near tidal inlet facies. These sands are cleaner and mature than the equivalent deltaic sandstones because of wave and tidal reworking. The shales are dark grey with greyish water fauna. In the landward side they grade into lithic-sandstones of fluvio-deltaic origin. The lower delta plain facies as interpreted in Rudrasagar area, prograded towards east-southeast and succeeded the barrier and back-barrier facies. Viewed from this angle, it is thought that in east and southeast, the Barail Main Sand (BMS) may occur at stratigraphically younger and higher portion and its equivalent units in landward side represent upper delta plain to alluvial facies (Fig. 10).

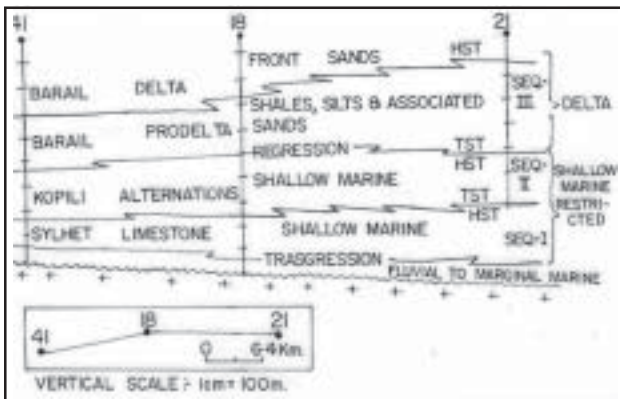


Fig. 10. Reconstruction of paleogeography during Paleogene Time, Upper Assam. (Modified after Madam Mohan, 1975).

Conclusions

- The Barail Main Sand (BMS) i.e the Seq. III in Assam Shelf was deposited as deltaic progradational units as a late Highstand to Shelf Margin System Tract.
 - Unlike the lithostratigraphy nomenclature, a prodelta to marine shale unit equivalent of BMS has been separated from the underlying Kopili unit, which helped bringing the depositional model more lucidly.
 - It represents a normal regression deposited to high sediment influx during this time.
- Though, the source seems to be from west and northwest i.e.the Indian craton, input from the orogenic front cannot be ruled out in this tectonically complex region.
 - The rapid thickening of Seq. III sediments towards east and southeast direction must have occurred during the times and in areas of rapid subsidence and rapid sedimentation.

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