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Fluvial Sequence Stratigraphic Analysis of Oligo-Miocene Sediments of Upper Assam Forel and Basin, India using Well Logs and Seismic Data

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Summary

Oligo-Miocene clastic rocks of the upper Assam basin deposited in an assymetrical foreland basin formed during the collision of Burma microplate with Indian plate. In this study core, well log and seismic data has been used for interpretation of fluvial sequence stratigraphic architecture of the basin. The fluvial stratigraphic record of Upper Assam basin is mainly controlled by eustasy, subsidence, source area upliftment and sediment supply. The Oligo- Miocene tectono-sequences composed of lower Barail sequence and upper Tipam prograding sequences separated by an unconformity surface. The stratigraphic section from Barail- Tipam sandstone in this study is divided in to succession of inferred tracts Transgressive system tracts (TST) and highstand system tracts (HST). Well logs and seismic data show the depositional environments is deltaic to fluvial during Oligo- Miocene period.

Introduction

The Upper Assam Basin (Fig.1) is a composite foreland basin which is located between the eastern Himalayn foot hills and the Assam- Arakan thrust belt. The basin is terminated to the northeast by the Mishimi Hills block and to the Southwest it is partly disrupted by the Shilong plateau basement uplift. In the subsurface, a ridge of Precambrian rocks known as Brahmaputra arch roughly bisects the Assam Basin. The arch plunges northeast ward from outcrops in the Mikir Hills to the northeastern part of the basin, where the plunge of the arch becomes northerly. The Paleocene and Eocene units thin and lap out against the arch, overlying Oligocene and Miocene units thin over it. Sediments on the south flank of the arch are cut by normal faults that roughly parallel and deep away from the axis of the arch (Bhanadari et al., 1973; Das Gupta and Biswas, 2000).

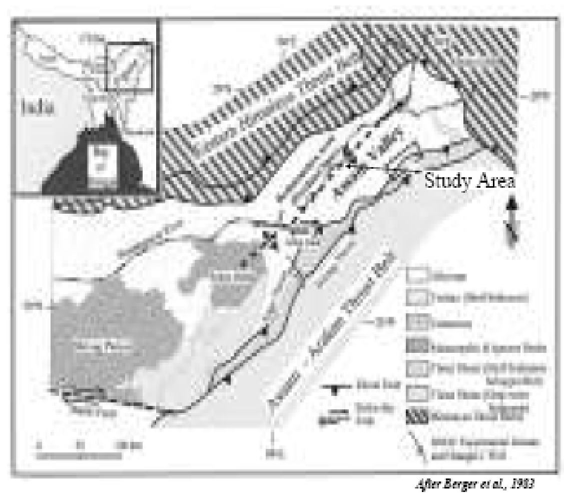


Fig.1 Location and major structural elements of Upper Assam Basin

General Geology and Stratigraphy:

Stratigraphy of the region has been dealt with in detail by various authors (Mathur and Evans, 1964: Raju, 1968: Bhandari et.al, 1973: Dasgupta, 1977: Rao, 1983: Murthy, 1983: Singh et.al, 1986: Ganju and Khar, 1985, Deshpande et.al, 1993 and other authors).

The upper Assam Basin and Naga Hills, which make up the frontal part of the northern Assam – Arakan thrust belt share a common Tertiary stratigraphy. The Tertiary sequence is divided into paleogene and Neogene sequences that are separated by major Oligocene unconformity (Raju & Mathur, 1995).

The generalized stratigraphic column of Upper Assam Basin consists of Archean metamorphic Basement overlain by Jaintia Group of Paleocene to Eocene age consisting of Tura, Sylhet and Kopili formations. The Barail group sediments of Disangmukh, Demulgoan and Rudrasagar formations of Eocene to Oligocene age overlies pre-Barail sediments and overlain by Tipam group of Miocene to Pliocene age consisting of Geleki sandstone, Lakwa Sandstone, Girujan Clay & Nazira Sandstone. Moran group of younger and recent sediments of Plio-Pliestocene to Recent ages comprising of Namsang, Dhekiajuli &Alluvium formations (Fig.2)

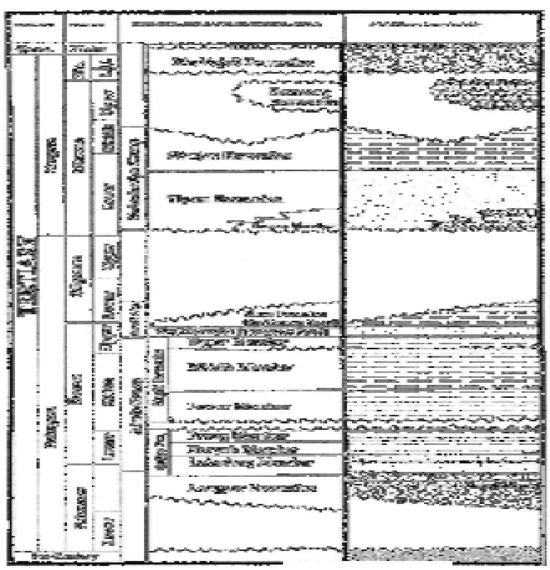


Fig.2 Generalised Stratigraphic column of upper Assam Basin

Theory and Concepts:

The fluvial stratigraphic record of Upper Assam basin is mainly controlled by eustasy, subsidence, source area upliftment and sediment supply. In the Assam foreland basin, high rates of subsidence characterize the main thrust controlled depocentre is formed by downwraping of the foreland plate by tectonic loading (Fig.3). As an elastic response to thrust loading, peripheral upwraping occurs at the distal margin of the basin produces an arch known as Brahmaputra arch. Because of the dominance of tectonics over eustasy on the basin evolution in the upper Assam basin, the sequences thus formed are called tectonosequences and are characterized by extensive angular unconformity at their base and top (Miall, 1997).

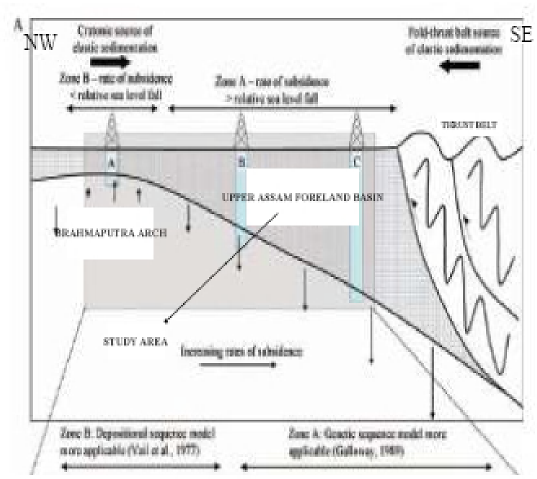


Fig.3 Schematic Upper Assam foreland basin showing the source of clastic sedimentation and relative rate of subsidence

The Oligo- Miocene clastic sediments represents the interplay between four regime variables (subsidence, tectonic upliftment, eustasy and sediment supply) and for applying stratigraphic concepts to both flooding surfaces (Galloway, 1989) and sequence boundaries (Vail et al., 1977) in tectonically active basin. The Oligo- Miocene clastic sediments deposited in the basin by upliftment and erosion that coincides middle Oligocene global – eustatic lowstand system tract. From the stratigraphic record of upper Assam, the Naharkatiya group unconformably overlying the Barail group is largely of fluvial origin and contains the heavy minerals (Bhandari et al., 1973) indicates that are derived from metamorphic complex of rising Himalayas.The stratigraphic configuration of tectonosequence is mainly controlled by subsidence, upliftment to a lesser extent by sediment supply and eustasy. The eustasy and sediment supply controls the stratigraphic geometries of (<3 m.y). Two distinctive zones of subsidence and sedimentation described in foreland basins (Posamentier and Allen, 1993) that is applied to Assam foreland basins (1) Zone A is the area adjacent to the thrust belt where the rate of subsidence exceeds the rate of eustatic fall; and (2) zone B is the area near Brahmaputra arch rate of eustatic fall exceeds the rate of subsidence. The subsidence history of various fields indicated that rapid subsidence takes place in late Eocene to early Oligocene time in the basin (Fig.4). This subsidence will determine over all geometries of depositional sequences and also controls the types of sequence boundaries produced.

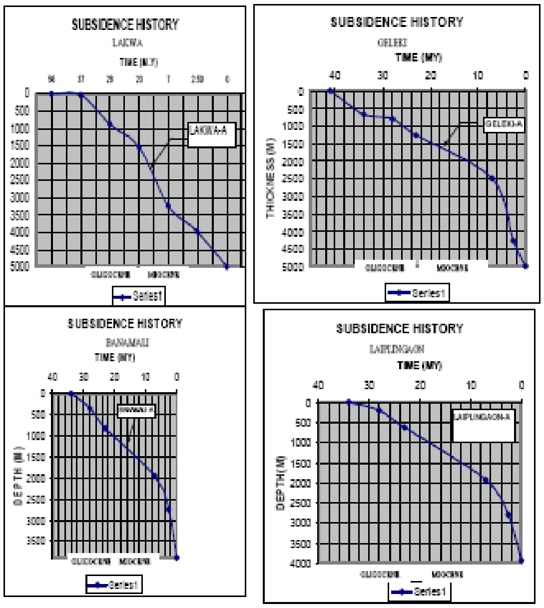
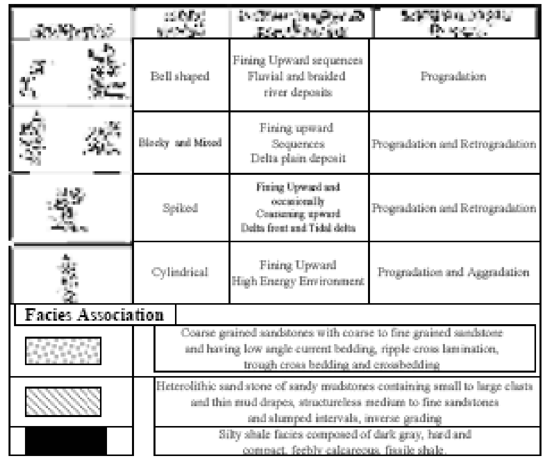


Fig.4 Subsidence history of various fields in the basin The main objective of this paper is the presentation of the fluvial records, its interpretation, depositional facies association environment using well logs and available seismic data. The Oligo-Miocene tectonic sequence is controlled by higher subsidence rate zone A over most of the basin, the recognition of flooding surfaces (Galloway, 1989) is adopted for the analysis.

Well Data and Facies Association:

Core data and its description in (Oligocene age) Barail formation level and (Miocene age) Tipam formation level was very helpful for the reconstruction of fluvial facies architecture. Drill cutting samples and its description along with log data provide valuable information where core data is limited. The observations of core along with calibrations of log curves to provide the age and boundary control. Facies in cores are classified into three main facies (Fig.5) (1) Sandstone Facies range from coarse to fine grained sandstone and having low angle current bedding, ripple cross lamination, trough cross bedding and crossbedding (current and ripple action). (2) Heterolithic facies with contorted bedding composed of sandy mudstones containing small to large clasts and thin mud drapes, structureless medium to fine sandstones and slumped intervals, inverse grading is observed. (3) Silty shale facies composed of dark gray, hard and compact, feebly calcareous, fissile shale. Shales are sideritic and silty lenses of fine sandstones are present.



[illegible]	[illegible]	[illegible]	[illegible]
	Bell shaped	Fining Upward sequences Fluvial and braided river deposits	Progradation
	Blocky and Mixed	Fining upward Sequences Delta plain deposit	Progradation and Retrogradation
	Spiked	Fining Upward and occasionally Coarsening upward Delta front and Tidal delta	Progradation and Retrogradation
	Cylindrical	Fining Upward High Energy Environment	Progradation and Aggradation

Facies Association

	Coarse grained sandstones with coarse to fine grained sandstone and having low angle current bedding, ripple cross lamination, trough cross bedding and crossbedding
	Heterolithic sand stone of sandy mudstones containing small to large clasts and thin mud drapes, structureless medium to fine sandstones and slumped intervals, inverse grading
	Silty shale facies composed of dark gray, hard and compact, feebly calcareous, fissile shale.

Fig.5 Lithologic facies used in Oligo – Miocene clastic rocks from core data

The age control in wells relies on biostratigraphic analysis indicates in Geleki and Nazira structures , the Disangmukh formation contains arenaceous foraminifera comprising

Ammobaculites sp., Miliammina sp., Spirillonoids sp., Spiroplectammina sp., Lituola sp. and Gaudryina sp.. Rudrasagar Formation contains arenaceous foraminifera which includes Cyclamina sp., Ammodiscus sp., Haplophragmoides sp., Miliammina sp. and Ammobaculites sp. etc and Neogene sediments are devoid of foraminifera(Un pub. Report, ONGC, Doc. – X, 1993)

Depositional environment:

Gamma-ray facies associations were adopted using gammaray and core description correlations. (1) Cylindrical and fining upward indicated high energy environment braided river processes (2) Blocky and fining-upward indicate delta plain environment (3) Bell shaped fining upward sequences (4) Spiky fining upward sequences of delta plain environment (Fig.5).

Sequence Stratigraphy:

Fig.6A and Fig.6B shows the stratigraphic analysis performed in this study using stacking patterns. The Oligo-Miocene tectono-sequences composed of lower Barail sequence and upper Tipam prograding sequences separated by an unconformity surface. The stratigraphic section from Barail- Tipam sandstone in this study is divided in to succession of inferred tracts, transgressive system tracts (TST) and highstand system tracts (HST). These sequence tracts bounded by flooding surfaces (FS). These stratigraphic surfaces and tracts are inferred primarily from lithologic data and gamaray log profiles.The Oligocene tectono-sequence is characterized by progradational sequence followed by retrogradational sequence of shale and at the top succession of progradational sequence of Tipam group. The intra Barail (Oligocene) include 6 flooding – surfaces . These surfaces are the main bounding surfaces that together define 7 parasequence sets. The maximum flooding surface is chosen based on the stacking patterns. The top of the Oligo- Miocene tectonosequence that is Geleki sandstone is of progradational sequence where the sediment influx is higher than the accommodation space created due to tectonics or subsidence. The middle Lower clay Marker is believed to be deposited in aggradational sequence followed by Lakwa sandstone again is of progradational in nature (Fig.7).

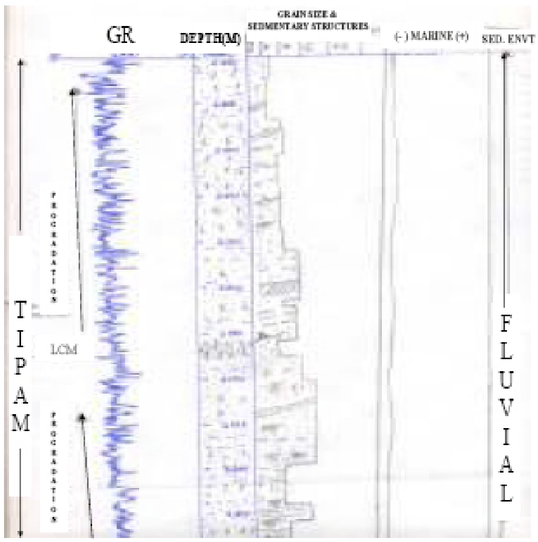


Fig.6A Stratigraphic interpretation showing vertical stacking pattern of progradation and retrogradation in Oligo- Miocene sequences and para sequences.

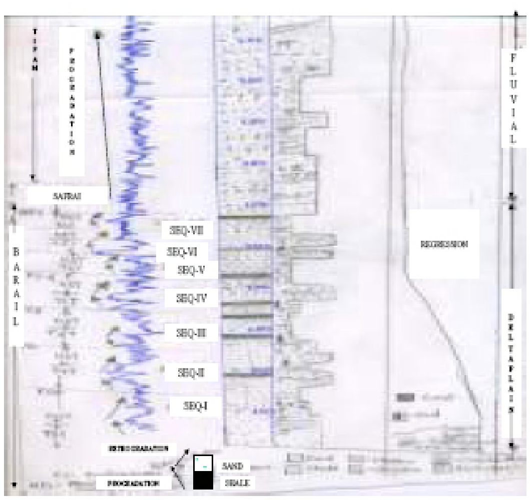


Fig.6B Stratigraphic interpretation showing vertical stacking pattern of progradation and retrogradation in Oligo- Miocene sequences and para sequences

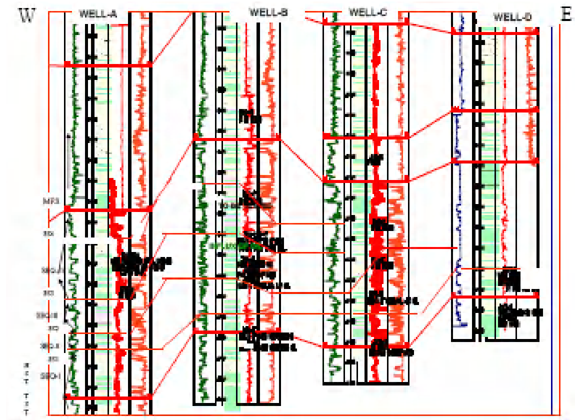
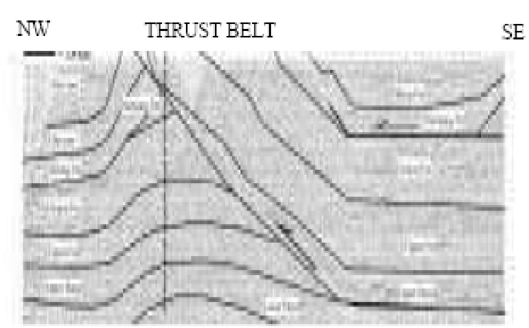


Fig.7 Well log Correlation in W-E direction showing different parasequences and maximum flooding surface (MFS)

Seismic Stratigraphy:

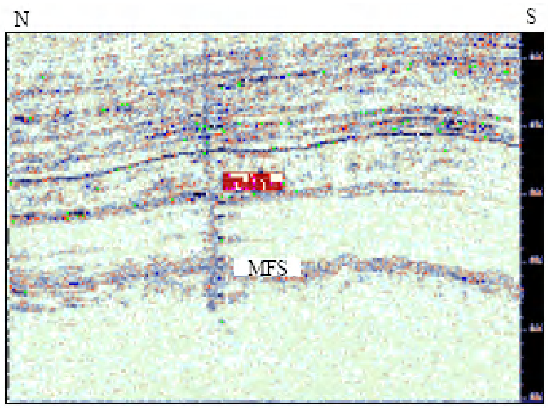
Fig.8, Fig.9, Fig.10, Fig.11 shows seismic section in NW-SE, N-S and NW-SE direction in different fields of the study area.. Well data is calibrated with the seismic data and it has been observed that Oligocene – Miocene tectono-sequence is an asymmetrical wedge and is thinning in NW direction and thickening in SE direction. An attempt is made to apply the maximum flooding surface and sequence boundary concept in the study area. Reflection pattern suggest pronounced lateral variations of depositional environments and lithologies in the study area. Fluvial and deltaic facies are dominant on well logs patterns and expressed as continuous reflections in seismic sections as shown in (Fig.9). This interpretation supports that the main source of clastic sedimentation from NW in Oligo - Miocene time in the study area.



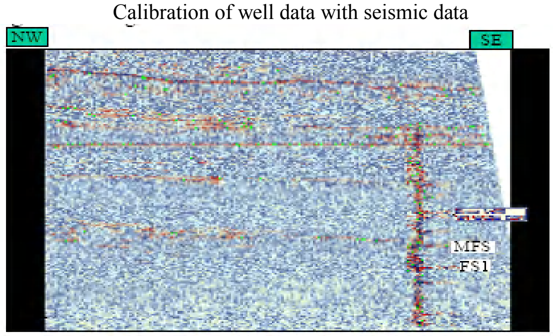
SEISMIC LINE D-50 ADOPTED FROM AAPG Bulletin after Kent et al.,2002

Fig.8 Seismic Line D-58 with interpretation

Fig.9 Seismic section along NW-SE direction of Geleki field



Calibration of well data with seismic data



Calibration of well data with seismic data

Fig.11 Well log calibrated with seismic data

Parasequence –I

The parasequence-1 tend to be progradational near the base and retrogradational near the top (Fig.6A & Fig.6B) and are characterized by mainly of sandstones with minor shales and separated from parasequence-2 significant flooding surface (FS1). This unit is deposited in delta front environment.

Parasequence-II

The contact between parasequence1 and parasequence2 is gradational and characterized by transgressive system tract(TST) and highstand system tract (HST) at the top (Fig.6B). The unit comprises of shale with thin bands of coal and sand and considered a fluvial point bar deposit.

Parasequence-III

This parasequence is demarcated by persistene coal bed and sand bodies and characterized by initial transgressive sytem tract(TST) and highstand system tracts at the top and deposited in meandering channel process (Fig.6B).

Parasequence-IV

This parasequence consists of silty sand and fining upward sequence with progradational trend at base and retrogradational trend at top and also considered to be a point bar deposit and deposited in meandering channel processes (Fig.6B).

Parasequence-V

This parasequence is demaracated with top and bottom flooding surfaces and characterized cross bedded fine grained sandstone with sigmoidal crossbedding shown in (Fig.6B). This unit is deposited under tidal channel environment.

Parasequence-VI

The parasequence shows combination of fining upward silty sand and clean sand sequence with progradation at base and retrogradation at the top (Fig.6B). The log characteristics indicates a point bar meandering channel processes.

Parasequence-VII

This parasequence is the topmost unit consists of shale, coal and sandstone and separated from the other sequence with a maximum flooding surface(MFS) (Fig.6B). This unit is demarcated itself as a channel fill deposit and bounded by the sequence boundary at top.

Depositional progradational sequence

This sequence comprises mainly fluviatile sediments and are classified on the basis of their stratal relations and lithologies (Fig.6A). The base part is valley fill deposit and are coarse clastics of Safrai member and are distinguished on seismic section (Fig.10 & Fig.11). The top of the formation (LCM) is a continuous high amplitude surface and is in aggradational trend where sediment supply is just matched with rate of subsidence. The Geleki and Lakwa sandstones are progradational in nature (Fig.6A) where sediment supply exceeded the rate of subsidence.

Implications for Hydrocarbon Exploration and Reservoir modeling:

The application of sequence stratigraphic principle has considerable predictive value addition to define the distribution and internal heterogeneity of reservoir bodies. The classification of the reservoir into separate flow compartments, their relationship to each other and their internal facies composition are determined by balance between sediment supply and accommodation space. The stacking patterns and internal geometry of reservoir units provides valuable clue for reducing risk to wildcat drilling. Further, the relationship of the sequence stratigraphic architecture to regional tectonic events is a critical component of basin analysis. The subsidence and maturation history investigation and use of appropriate sequence model is critical understanding basin architecture and reservoir modeling.

Conclusions:

The stratigraphic architecture of the Oligo- Miocene period was controlled by variable tectonic subsidence rates and variable degree of sediment supply and it has been observed that eustasy has limited role during this period. The Oligo-Miocene facies are interpreted as fluvial braided process in Miocene time and delta plain of meandering river channel process of Oligocene time. The genetic sequences were interpreted when rate of subsidence higher than eustatic sealevel fall in zone A and depositional sequence interpreted formed when rates of eustatic sea level fall were higher than subsidence rates in zone B.The application of Gamma ray log profiles along with seismic data yield a reliable geologic model provide better understanding of the foreland stratigraphy of the area.

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Note: Views expressed in the paper are authors only

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