Sasanka Sekhar Deb, Oil India Ltd, E-mail sasankadeb@yahoo.co.in
Indrajit Barua, Oil India Ltd, E-mail indrajitbarua@oilindia.in
B.P.Sarma, Oil India Ltd, E-mail bpsarma@oilindia.in

Prospects identification and future exploration strategy in Palaeocene/Eocene formations of Basement High and adjoining areas in Upper Assam Basin based on palaeoenvironment.

Introduction:

Identification of loci for hydrocarbon entrapment based on depositional environment is a well known technique in hydrocarbon exploration. Environment has direct impact on shape, size and type of trap available in a particular area. Eocene- Palaeocene sediments (LK+Th and Langpar formation) in Basement High area of the Upper Assam Basin were deposited in shallow marine to fluvial condition and considered as most potential sediments for hydrocarbon accumulation point of view. More than 15 geological structures have been successfully explored in the Basement High and its adjoining area so far, with commercial production of hydrocarbon (Fig1).However, reservoir quality, extent and productivity vary from place to place. The primary reason could be the depositional setting of the reservoir units. An attempt has been made to identify trap type in the present study, likely to be available in OIL,s operational area as a guide for future exploration.

Study area:

The Upper Assam Basin is a well known petroliferous sedimentary basin of India. Exploration for hydrocarbon started way back in 1866 and commercial oil was first discovered in 1889 in Digboi. The Basin is bounded in the north by the Eastern Himalayas, in the east by the Mishmi Massif, in the south by the Naga-Patkai Hills and in the west by the Mikir Hills and Shillong Plateau . A thick pile of sediment ranging in age from Cretaceous to Pleistocene has been deposited in the Basin. Commercial hydrocarbon production from Palaeocene to Mio-pliocene sediments have been established till date. A Basement High trend running along the central part of the Basin is an important structural feature from the hydrocarbon entrapment point of view in the Basin. The sediment thickness increases on either side of the 'high' .In this paper primary focus is on the depositional pattern of the hydrocarbon rich Palaeocene- Eocene sediments of Basement High and nearby area of the Basin .

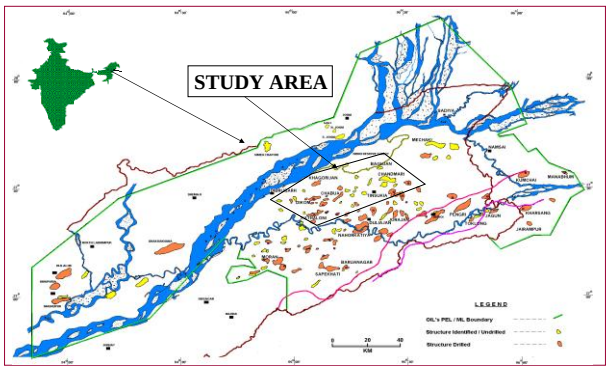


Fig: 1 Location map

The study area covers around 4000 sq.km with more than 175 wells drilled up to Eocene/Palaeocene section (Fig.1). The main hydrocarbon potential is confined to the

Langpar and Lower part of Sylhet Formation (Lakadong and Therria unit). Generalized stratigraphic succession of the Basin is presented in Text table

Age		Group	Formation
Pleistocene		Alluvium	
TERTIARY	Pliocene	Dihing Group	Dhekiajuli Formation
	Miocene	Dupitila Group	Namsang Formation
		Tipam Group	Girujan Formation
			Tipam Formation
	Oligocene	Barail Group	Argillaceous Unit
			Arenaceous Unit
	Eocene	Jaintia Group	Kopili Formation
			Sylhet Formation
	Palaeocene		Langpar Formation
Cretaceous			Dergaon Formation
Pre Cambrian			Basement

Text Table-1: Generalized Stratigraphic Succession of Upper Assam Basin

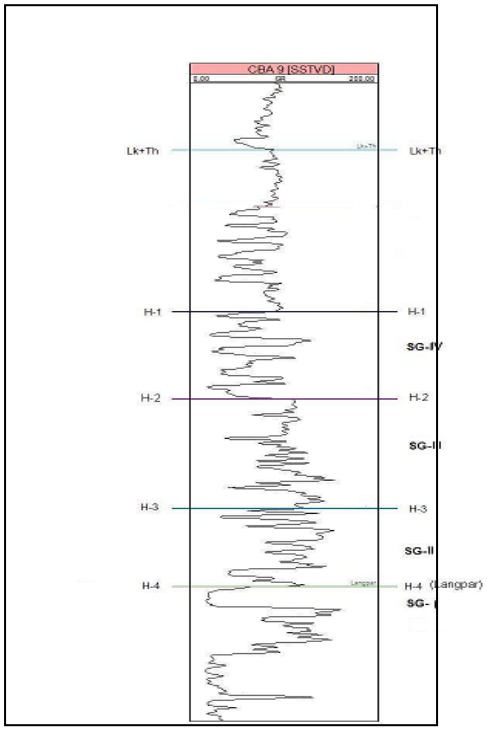


Figure: 2 Sand Group identification

More than fifteen structures have been explored in the study area so far, with the establishment of successful commercial production. These sediments consist of thin multistacked clastic reservoirs which have good to very good reservoir quality and variable production potential. One reason for the variation in reservoir quality could be the depositional setting . An attempt has been made in the current study to understand the depositional environment of the main potential reservoir zones based on sand shale ratio data, core data and log responses in the light of sequence stratigraphic concepts.

Approach:

Based on sequence stratigraphic concepts the entire LK+Th reservoirs section have been divided in four subgroups and top part of Langpar formation identified as one subgroup (Fig 2). Palaeogeological maps have been prepared based on sand shale ratio to get a clear picture on depositional pattern of these sediments (Fig 7-10). A wide variation of depositional environment of these sediments in the different structures have been observed from these maps. Tentative position of the palaeoshore line has also been identified to have a better idea about the type of deposition. Based on depositional setting four main depositional types have been identified to give systematic approach for better understanding of the play type pattern.

Type of Deposition:

Fluvial deposits: Deposition which takes place along a river course in the continental part of a basin is known as fluvial deposits. Mainly three types of fluvial deposits are found in a channel course viz. Alluvial Fan deposits, Braided deposits and Meandering deposits. Alluvial fans are typically lobate in plan view and wedge/lenticular in cross section (Fig.3).

These deposits consist commonly of coarse-grained, matrix-rich conglomerates, extremely poorly sorted deposits with rarely developed sedimentary structures and mainly of debris-flow origin. This type of deposits are generally observed in upstream channel part near the foot hill area /transition from very high gradient to low gradient of channel.

Fig.- 3 Aerial view of an alluvial fan .

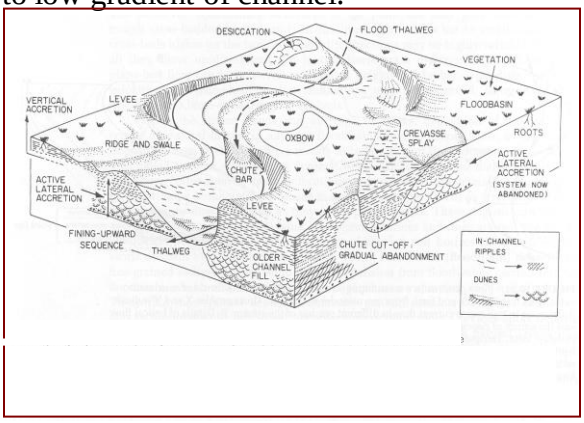


Fig. 4 The morphological elements of a meandering-river system

In braided deposits, not very clear cut demarcation can be made with alluvial fan deposits but in general they are less coarser than alluvial fan deposits and some time contains sedimentary structure. Braided rivers are characterized by large bedforms called bar. Bars are normally oriented with their long axis roughly parallel to current flow. Coarsest material is concentrated along the central axis and bottom of the bar, and grain size tends to decrease upwards and downstream. Gamma-ray wireline log signature is blocky in nature.

Meandering deposits are characterized by fining upward grain size trend. It has five different type of deposition within the meandering stream system: i) main channel ii) point bars iii) natural levees iv) the floodbasin and v) oxbow lakes meander cutoffs. Each of these subenvironments of the system generates deposits with characteristic grain sizes and sedimentary structures(Fig 4). Sand shale ratio is very high compared to sea ward deposits.

Delta deposits: Deposition take place in the mouth of a river where flow runs into standing sea/lake water (Fig.5) . A delta is a fan shaped deposit of sediments at the exit of a river into a larger body of water (Fig.6). Normally medium to fine grained well sorted sandstone deposits are encountered with subangular to subrounded in texture. Sand shale ratio is relatively very high compared to sea ward deposits.

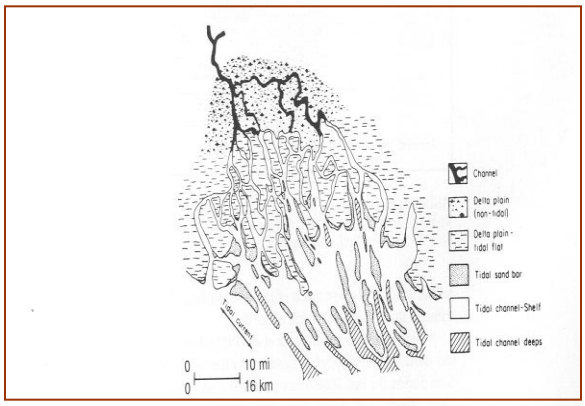


Fig:5 The modern tide-dominated delta.

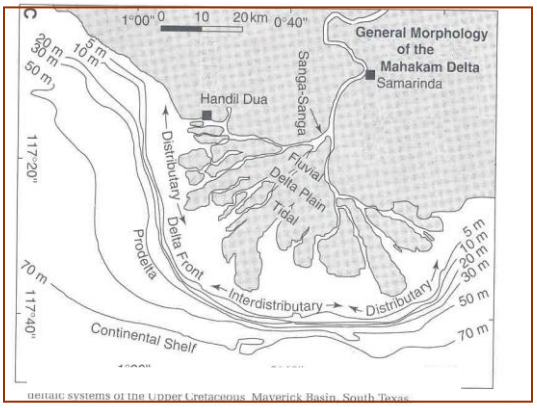


Fig:6 Deltaic systems of the Upper Cretaceous Maverick Basin, South Texas

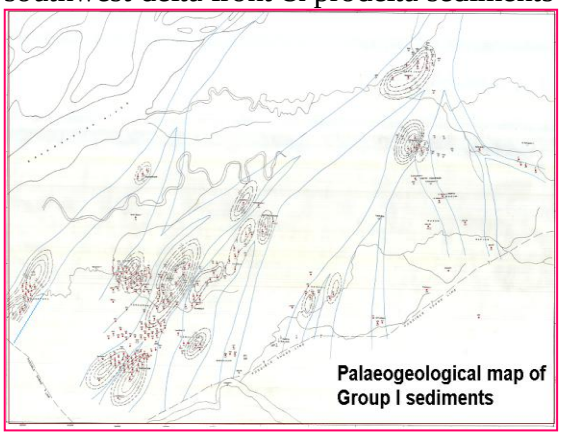
Delta front deposits: Sediments deposited seaward of the shoreline on a delta is known as delta front deposits(Fig.6), where the coarsest marine sediments are found. This area can be reworked by waves etc. Delta front deposits represent the most dynamic part of a delta system. High variability of interaction between fluvial and marine processes within the delta front area suggests a complex architecture of delta front deposits. Sand shale ratio is on the lower side.

Pro-delta deposits: Fine grained silt/sand to clay deposition takes place further seaward of the delta front deposits (Fig.6). These muddy build ups are referred as the Prodelta Zone. Sand shale ratio is much lower than the delta front deposits .

Depositional environment and play type:

Four main sub-groups have been studied in detail for depositional environment vis-a-vis trap geometry. All the groups have different geological setting as evident from the palaeogeological maps.

The deposition of the Group-I sediments took place in a fluvial environment and the direction of channel flow was from north-northeast (Fig 7). Accordingly, there is a strong possibility of encountering more fluvial braided and alluvial fan deposits towards north-northeast direction. On the other hand, near the possible shore line deltaic and further south-southwest delta front & prodelta sediments should have been deposited.



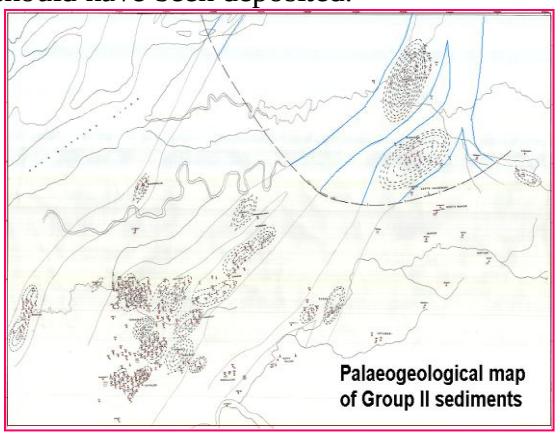
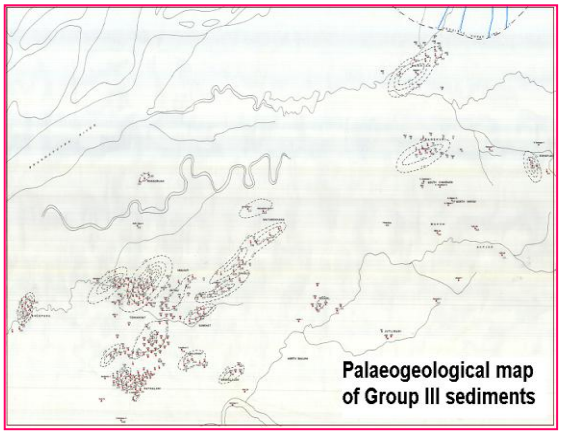


Fig. 7 Palaeogeological map of SG-I Fig.8 Palaeogeological map of SG-II

The Group-II sediments show variation of environment from delta front to fluvial deposits (Fig 8). Extension of fluvial deposition can be expected till the low relief of high mountain/foothill area in north-northeastern direction. Deltaic sediments of the same channels could be deposited near shore line area. But in the southwest of the study area and further southwest, possibility of deposition of delta front and prodelta deposits with average to poor quality reservoir is highly probable.

The overlying zone (Group-III) were deposited in shallow marine environment in the study area (Fig 9).The position of the shore line should be in the north/northeast of Baghjan area. A deltaic/fluvial deposition should have taken place in the upstream channel direction. On the contrary, small deltafront /prodelta deposition is expected in the southwest direction.



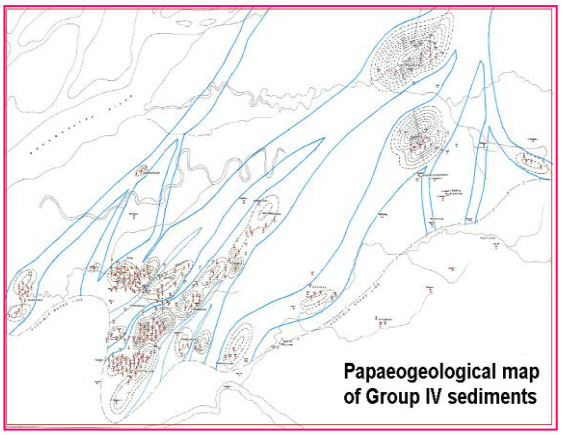


Fig : 9 Palaeogeological map of SG-III Fig : 10 Palaeogeological map of SG-IV

The Group IV sediments were deposited in near shore environment in south western part and fluvial environment in north eastern part (Fig 10). Beyond the deltaic deposition, an obvious delta front and prodelta deposition towards seaward direction is expected. But in the upstream channel direction, fluvial meandering & braided deposition should have been taken place till it encountered alluvial fan deposits beyond Baghjan area.

One interesting point in regard to the uppermost sediments of Lk+Th is that the calcareous nature of the reservoir zone changes towards the northern part of the study area. If the same trend continue then possibility of encountering fluvial deposits towards further north is highly possible. But in shallow marine part delta front and prodelta deposition could have been a possibility .

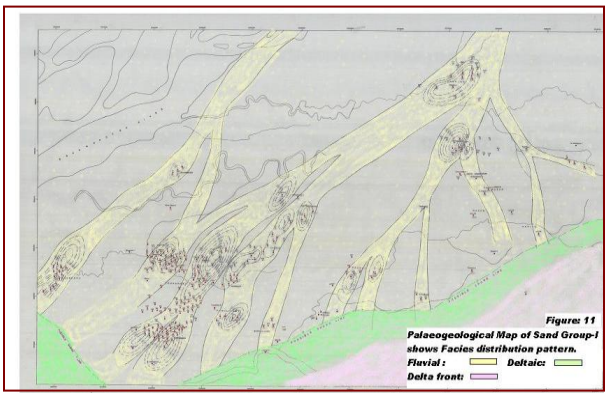
Due to data limitation depositional environment of north-west and southeast of Basement High area can not be evaluated with confidence.

Discussion and Conclusion:

It is evident from the above that the depositional setting and corresponding reservoir quality of Palaeocene /Eocene sediments of the study area can be identified based on the above study. Accordingly, the results of the study can be used as a guide for future exploration.

For Group-I fluvial deposits of mainly meandering origin were deposited throughout the study area. Therefore, braided and alluvial fan deposits are expected in N-NE of the study area. On the other hand, beyond Kathaloni and Bhogpara areas (located towards SW of the study area) possibility of encountering deltaic deposits with very good reservoir characteristics and further sea ward delta front deposits of small size structure with good to fair quality reservoir rock is a distinct possibility (Figure-11).

Figure. 12 illustrates the depositional setting of Group-II sediments . It is evident from the figure that fluvial deposits of upstream channel characteristic should be present beyond Baghjan area towards N/NE direction . It is inferred that a possible deltaic deposition should be taken place near the shoreline area. Beyond this area possibility of encountering delta front and prodelta deposits are expected in S/SW/SE direction.



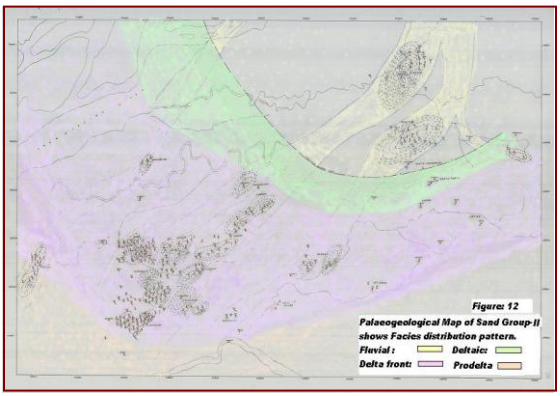
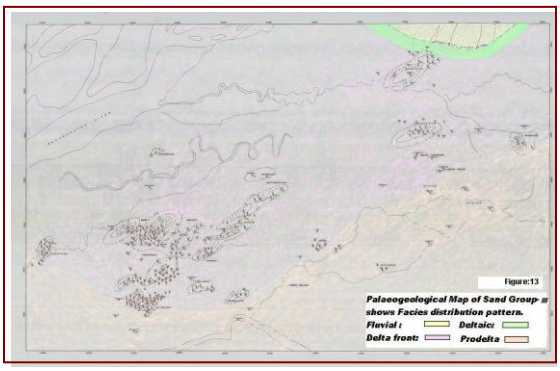


Fig : 11 Facies distribution map of SG-I Fig : 12 Facies distribution map of SG-II

Delta front and Pro-delta deposits dominate the Group-III sediments, so good sediment accumulation with good reservoirs quality can be expected near the shore line area and further in the upstream direction. With similar depositional pattern, more braided and alluvial fan deposits are expected in the N/NE of Baghjan area (Figure 13).



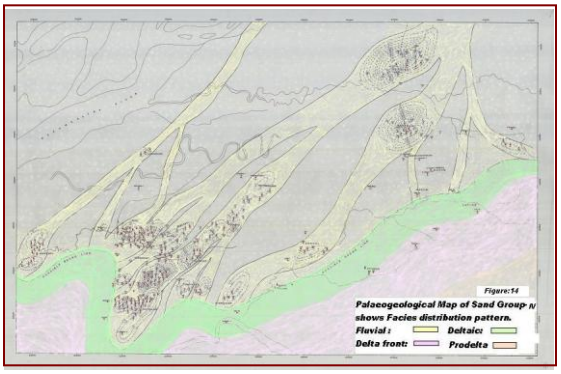


Fig : 13 Facies distribution map of SG-III Fig : 14 Facies distribution map of SG- IV

In case of Group IV sediments, deltaic to fluvial (meandering + braided) deposition took place in the entire study area .So , possibility of encountering fluvial (alluvial fan) deposits of large size in the upstream direction and in the down stream direction from the birdfoot delta area a relatively smaller delta front and prodelta deposits with variable reservoir quality depositions are expected. Large unexplored area within the study area where fluvial channel deposits align along channel course is highly probable(Figure 14).

The overlying sediments of LK+TH above the Group-IV also show changes in depositional pattern from shallow marine quiet environment to fluvial, almost similar in trend to the underlying sediments of Group-II.

The study suggests that there has been an increase in fluvial influence towards north-northeast direction for all groups including the calcareous group. So possibility of the existence of large continental deposits having very good reservoir quality beyond Baghjan area is very high. Large part of area between Matimekhana/Khagorijan and Baghjan/Barekuri structures remain unexplored that hold prospects for all groups. In the western part of the study area small deltafront /prodelta deposits with good to fair reservoir quality traps is expected ,except for the Group -I sediments.

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