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RESEARCH ARTICLE

LITHOFACIES AND PALAEOENVIRONMENTAL RECONSTRUCTION OF PALAEOGENE DISANG – BARAIL TRANSITIONAL SEQUENCE IN PARTS OF KOHIMA SYNCLINORIUM, NAGA HILLS, NORTH-EAST INDIA

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ABSTRACT

The Palaeogene Disang - Barail Transitional Sequence (DBTS) developed at the tip of Kohima Synclinorium, Naga Hills have been analyzed for their litho-facies characteristics using environment sensitive parameters viz. lithology, sedimentary structure, geometry, fossil content and palaeocurrent. A total number of six litho-facies – A: Sand – Conglomerate facies, B: Sand facies, C: Sand – Mud facies, D: Mud – Sand facies-i, E: Mud – Sand facies-ii & F: Debrite facies have been identified and studied along six vertical profile sections measured at different locations across the study area. A facies scheme depicting litho – facies interpretations in terms of processes has also been attempted. Based on the entire assemblage of characteristic sedimentary features of different litho-facies, a turbidite fed fan-slope depositional environment has been envisaged for the DBTS of the study area.

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INTRODUCTION

The Northeast India represents northern part of the Assam-Arakan orogenic province. Two orogenic belts warped around its northeastern corner marking the zone of plate convergence. The Himalayan belt on the north and the Assam-Arakan belt (IBR) on the southeast marks the collision front of the Indian plate with the amalgamated Indo-Sinian and Malaysian plates (Acharyya, 1991; Biswas *et al*., 1993). A north-south convergence of the Indo-Sinian plate culminated into an oblique collision (Dewey *et al*., 1989; Burchfiel, 1993; Uddin and Lundburg, 1998 a & b, Naik, 1998). In the Assam –Arakan region, suturing extended progressively southwestward like a zipper as the two continental plates converged obliquely with a pole in the Naga Hills region (Biswas and Agarwal, 1990). Most of the earlier workers have related the stratigraphic inconsistencies and along-strike changes in the crustal nature with those of the varied and complicated nature of tectonic regimes in the region. Three distinct facies -deep–sea flysch, shallow marine shelf and continental sediments (molasses) have been recognized by earlier workers. Marine shelf facies and continental facies together characterizes the Assam region where as deep-sea facies occurs in the Naga Hills (Brunnschweiler, 1966). The most prominent structural unit in the Inner Fold Belt of Naga Hills is the Kohima Synclinorium (Chakrabarti and Banerjee, 1988), a part of which forms the present area of investigation. Its western limits are defined by Halflong-Disang thrust and the eastern limits by Changrung-Zungki-Lainye thrust (Naik, 1998). The northern limb of this synclinorium forming the Barail ranges of North Cachar, extends south-westward below Halflong and then westward, fringing the eastern extension of Meghalaya plateau. The southern limb extends into west Manipur, East Cachar and East Mizoram. The core of synclinorium is occupied by Surma sediments. According to Nandy (1974) and Chakrabarti & Banerjee (1988) there exists a lithological dissimilarity among two limbs of the Kohima synclinorium. At the periphery of the Kohima Synclinorium, south of Halflong, there are underlying Disang sediments displaying a sequence of splintery shales with minor sandstones (Rao, 1983).

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Geology of the study area

The study area (Fig.1) forms a part of the Kohima Synclinorium lying at a distance of 4kms south of Kohima (Lat. 25^0 40’ N; Long. 94^0 08’E), a district headquarters and the capital town of Nagaland state bordering Manipur in the

NE India. It is bounded by Latitudes 25^0 32' N – 25^0 36' N, and Longitudes 94^0 05'E – $94^0$10'E and covers nearly 100 sq.kms of the topographic sheet no. 83 K/2 of Survey of India including Phesema, Kigwema, Jakhama, Viswema and Khuzama villages. Sediments of the study area do not exhibit lithological similarity with those of Disang as well as Barail group of rocks. The eastern half of the area is dominated by shale which gradationally passes into a succession having higher increments of sandstone beds (Fig.1). At places, multistoried sandstone units having similar attributes as those of the Barails are found to be overlain by thick succession of shale resembling Disangs. Due to the mixed lithological character of the sediment, the lithological units of the area have been considered to be part of the Disang-Barail Transitional Sequence (DBTS) (Srivastava *et al*., 2004).

Recognition of Lithofacies

Based on the five diagnostic parameters of sedimentary facies, viz. bed geometry, lithology (including grain-size), primary sedimentary structures, palaeocurrent patterns and biogenic remains; if any (Selley, 1970, & 1976); the entire assemblage of Disang – Barail Transitional lithology has been grouped into six distinct lithofacies types. Following Mutti and Ricci Lucchi (1972) & McCaffrey and Kneller (2001), these lithofacies were assigned specific codes, namely A, B, C, D, E & F and a facies scheme for the Palaeogene sequences of the study area was developed for the first time (Table.1).

A:This facies includes pebbly sandstones/conglomerates with little or almost nil inter bedded mud (Plate 1.1 a, b; 1.5 a). These are mostly confined to channels. Thickness of facies varies from 20 to 30cms. Individual beds are difficult to identify. In general, this facies exhibits a fining upwards trend with an erosional base. On an average it constitutes approximately 2.12 percent of the total section measured. The overall geometry of the lithofacies corresponds to that of a lenticular body. For descriptive purpose this lithofacies is being named as sand-conglomerate facies.

B:Fine to medium–grained thickly bedded sandstones having sporadic faint plane/low-angle lamination and dish structures are characteristic to this facies (Plate 1.1 c, d; 1.2 a, b, c, d; 1.3 a, c; 1.5 a, b). Sandstone units are mostly confined to channels (Plate.1.2 a) and display a lenticular bed geometry. Thickness of the lithofacies varies between 50.0 cm to 4.0 meter. On an average it constitutes approximately 15.69 percent of the total sections measured. For descriptive purposes this lithofacies is being designated as sand facies.

C:This facies consists mainly of massive graded sandstones (resembling massive division 'A' of the Bouma sequence) interbedded with a small proportion of mud rocks (Plate 1.1 d; 1.2 c, d ; 1.3 b; 1.4 d). It usually occupies the top of the coarsening and thickening upward sequences with an erosional base. The thickness of the facies constitutes 27.23 percent of the total sections measured. For descriptive purposes this facies is being named as sand-mud facies.

D:This facies is typically comprised of thin, laterally persistent layers of fine-grained sandstones (resemblance with 'B'/ 'C' division of Bouma sequence) interbedded with a substantial proportion of shale (Plate. 1.2 d; 1.3 d; 1.4 d; 1.8 a, b). At places the sandstone beds exhibit faint plane/wavy lamination with a sharp base and the top (Plate 1.2 d; 1.8 a). The overall geometry resembles those of shoestring bodies. Thickness of the facies varies between 1.5 to 23.0 meters. On an average this facies constitutes approximately 17.52 percent of the total sections measured. For descriptive purposes this facies is being designated as mud-sand facies-ı.

E:The physical appearance of this facies is almost similar to that of 'D' except for the sandstone layers which are relatively coarser, thicker and many are massive and lens out laterally. In, addition dominance of ripples; at places cross-lamination and absence of plane parallel/wavy laminations are diagnostic to this facies (Plate 1.4 a, b, c; d; 1.5 c, d; 1.6 c, d; 1.8 d). The overall thickness of the facies varies between 1.0 to 13.0 meters. On an average this lithofacies constitutes 18.66 percent of the total sections measured. For descriptive purpose this facies is being referred as mud-sand facies п.

F:This facies includes slumps and debris flow deposits encased within "sandwich beds" (Plate 1.6 a, b, c; 1.7 a, b, c, d; 1.8 c). Occurrence of gravel size sandstone clasts and deformed rafts of turbidite mudstone and sandstone (Plate. 1.6 a, b, c), with or without bioturbation structure within a matrix of sand is a conspicuous feature of this facies. Thickness of the lithofacies varies between 60.0 cm to 17.0 meters. This facies constitutes approximately 18.75 percent of the total sections measured. For descriptive purposes the lithofacies is being named as debrite facies.

Description of Vertical Profile Sections

To understand the time relationship and spatial distribution of different lithofacies types altogether six vertical profile sections were measured and carefully studied at various locations indicated in Figures 2 & 3.

Milestones-189 Section

This vertical profile section was measured along NH.39 at 189 milestones. In this section five lithofacies namely A, B, C, D & E are represented. In general, this section of 37 meters displays coarsening upward pattern towards the lower part followed by blocky arrangement and then fining upward cycles (Fig.2). The overall palaeocurrent direction is towards N270.

Dzucha Ru section

This vertical profile section was measured along the upper reaches of Dzucha Ru west of NH.39. Here four lithofacies types namely A, B, C & D are well represented. In this section of 86 meters superimposed coarsening and fining upward cycles are spectacularly developed (Fig. 2). The palaeocurrent direction varies between N75 to N334.

Phesa Quarry Section

This 57meters thick vertical profile section was measured along NH.39 nearly 1 km west of Phesama village. It exposes three well developed lithofacies namely B, C & E. Superimposed fining upward cycles are quite prominent (Fig.2). The palaeocurrent direction varies from N60 to N270.

Mezhu Ru Section

This vertical profile section was measured along NH.39 near 195 milestones. In this 28 meters thick vertical profile section

Table 1.

Facies Code	Litofacies	Definition	Probable Environ- mental Processes
A	Sand - Conglomerate	Channeled pebbly sandstone / conglomerate with or without thin layers of mud.	Meandering / braided channels in the submarine inner / midfan.
B	Sand	Fine to medium channeled / thick bedded, lenticular sandstone showing sporadic faint plane / low angle laminations and dish structure.	Shallow distributory channels in the submarine midfan.
C	Sand – Mud	Massive graded sandstone (Bauma Division 'A') interbedded with some mud rocks and occupying mostly the top of coarsening – and thickening – upward sequences.	Deposition by turbidity currents in the submarine outerfan.
D	Mud – Sand (I)	Alternating thin fine grained sandstone showing incomplete Bauma sequences (generally B or C division) and substantially thick shale. Beds are marked by their regularity and continuity laterally except for channelized sandstone pockets.	Deposition by turbidity currents in the submarine outerfan.
E	Mud – Sand (II)	Thin fine grained sandstone interbedded with substantial proportion of shale. Many sandstone beds are massive and lens out laterally. It shows spectacularly preserved ripples / ripple cross laminations and rarely contains Bauma divisions B & C.	Over bank deposits in the submarine inner and midfan.
F	Debrites	Slumps and debris flow deposits are common. These occur as distinctive unit – a sandwich bed in which slumps and debris flow deposits are encased. Occurrence of gravel sized sandstone clasts and deformed rafts of turbidite mudstone and sandstone with or without bioturbation structure within a matrix of sand is a conspicuous feature.	Turbidity current triggered debris flow deposition closer to slopes.

four lithofacies types namely B, C, E & F are well developed. This section is characterized by superimposed coarsening upwards cycles (Fig.3). The palaeocurrent direction varies between N20 and N145.

Upper Keho Ru Section

This vertical profile section was measured along the upper reaches of Keho Ru west of NH.39. There are four lithofacies types namely B, C, E & F comprising the section. This section of approximately 27 meters displays 80 percent of facies "F" and rest 20 percent B, C & E (Fig.3). No cyclic pattern could be established. The overall palaeocurrent direction is towards N280.

Lower Keho Ru Section

This vertical profile section was measured along the lower reaches of Keho Ru west of NH.39. In this section of 53 meters four lithofacies types namely B, C, E & F are well represented. The lower part of the section is characterized by fining and coarsening upward cycles, the middle by blocky arrangement while the top is occupied by fining upward cycle (Fig. 9). As compared to the Upper Keho Ru section, no apparent change in the palaeocurrent direction is noticed.

Lithofacies Scheme

A facies scheme depicting interpretations of lithofacies in terms of processes was developed for Palaeogene DBTS of the study area following Mutti and Ricci Lucchi, 1972; McCaffrey and Kneller, 2001 as shown in Table-1 below. An overall submarine turbidite related processes have been interpreted.

Palaeoenvironmental Reconstruction

Based on the lithofacies characteristics and their associations the following sub – environments of marine regime have been envisaged:

(i)Slope-Apron Fan Sub-Environment

Slope – aprons are the depositional environment that occupies the region between shelf and basin floor in a marine realm. Besides, continental slope and rise, they also occur on the flanks of oceanic ridges, isolated sea mounts and plateaus. The main morphological elements (Bouma *et al*., 1985: Doyle and Pilkey, 1979, Stow, 1986) include, a relatively abrupt shelf break, fault-scrap and reef – talus wedge, slump and slide scars, irregular slump and debris flow masses, small straight or slightly sinuous channels and gullies, more complex dendritic canyons, isolated lobes, mounds and drifts and broad area of smooth or current-molded surface. Mutti and Ricci Lucchi (1972) recognized two major facies associations - the upper slope-apron facies association and the lower slope-apron facies association. The former is characterized by dominance of bioturbated and evenly bedded mudstone and marlstone of mainly hemi pelagic origin but with some resedimented facies. Slumps scars and high energy erosional features are common. The lower slope – apron facies associations are also dominated by similar lithologies except for being finer grained. Large scale channels are cut through by fining upwards or irregular channel-fill sequences inter bedded with isolated debrites, slumps and slide masses.

In the present investigation, the inter bedded sequences of lithofacies 'F' and 'E' are assigned with the lower slope apron sub–environment based on the following characteristic features: -

i) Common association of debrites with channeled, fining upwards sequences of lithofacies 'E'.
ii) Encased slumps and debris flow deposits within 'Sandwich beds'.
iii) Occurrence of gravel size contorted mud and sand layers with or without bioturbation structures, mud clasts and small and big sand spheroids.
iv) Structureless and disorganized debrite deposits.

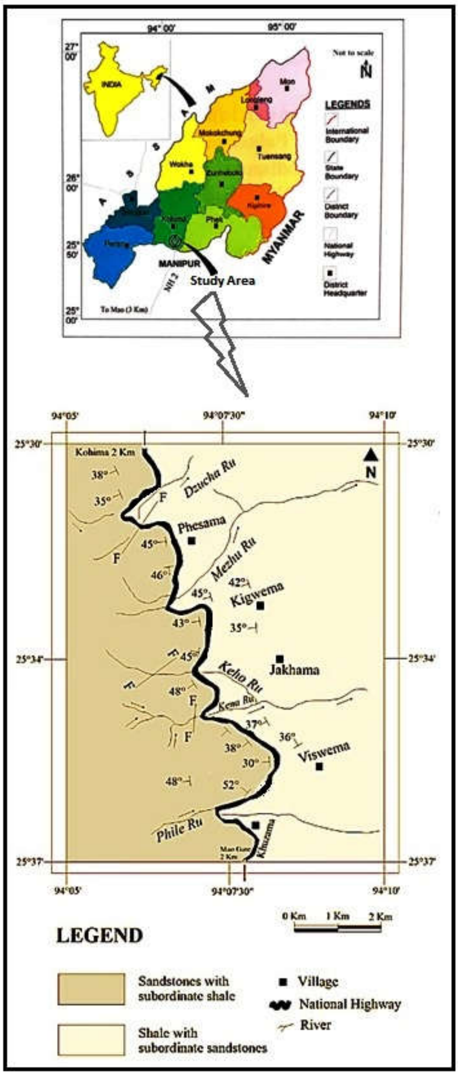

Fig. 1.

(ii)Deep-Sea Fan Sub-Environment

Deep-sea fans are distinctive constructional features at the foot of slopes, both in small shelf or marginal basins and large ocean basins. These are isolated bodies that develop seaward of a major sediment source (river, delta, glacier etc.) or main supply route (canyon, gulley, trough etc.). They comprise one or more feeder channels or canyons, tributary and distributary channels, abandoned half-filled channels, slumps and slide scars and blocks, debris flow masses, broad channel levees, lobes built up at the end of channels and distributaries, and relatively smooth or current molded inter channels and inter-lobe areas (Normark, 1970, 1978; Walker, 1978, Stow, 1981; 1985). Stow *et al*., (1984) identified two principal end-member types, i.e. radial fans and elongate fans with all possible gradations in between plus a third shallow water type i.e. fan delta. The basic process constructing submarine fan is the deposition of sediments from turbidity currents. In the present context, the lithofacies associations together with sedimentary structures and other characteristics bear similarly with those of inner, middle and outer submarine fan deposits as described by Mutti and Ricci Lucchi (1972), Following are the salient features of the Palaeogene DBTS favouring deposition in a deep – sea fan sub- environment.

i) Laterally impersistant beds of pebbly conglomerate showing erosional contact with underlying sediments. The content of interbedded mud is very little or almost nil. Occasionally, beds display normal grading and sharp/gradational contact with overlying sediments. These are chiefly confined to channel, the base of which usually display load structure. The facies is identified as ‘A’ and is found commonly associated with lithofacies ‘B’ and similarity with those of inner fan deposits.

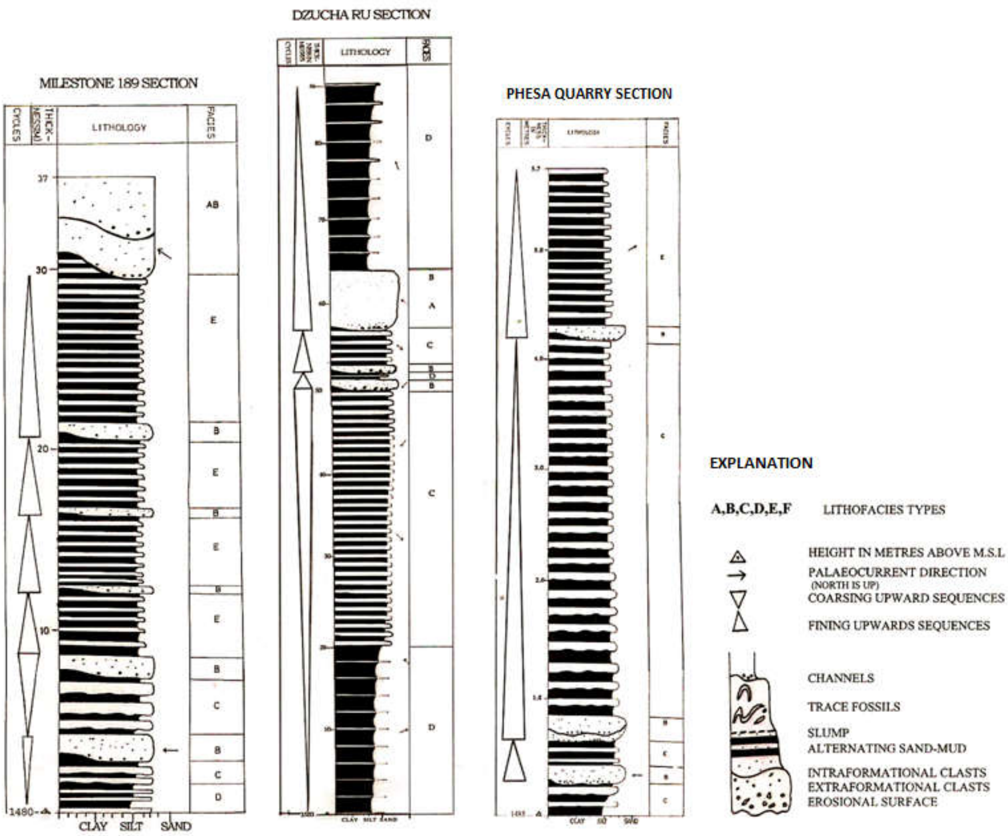

Fig. 2

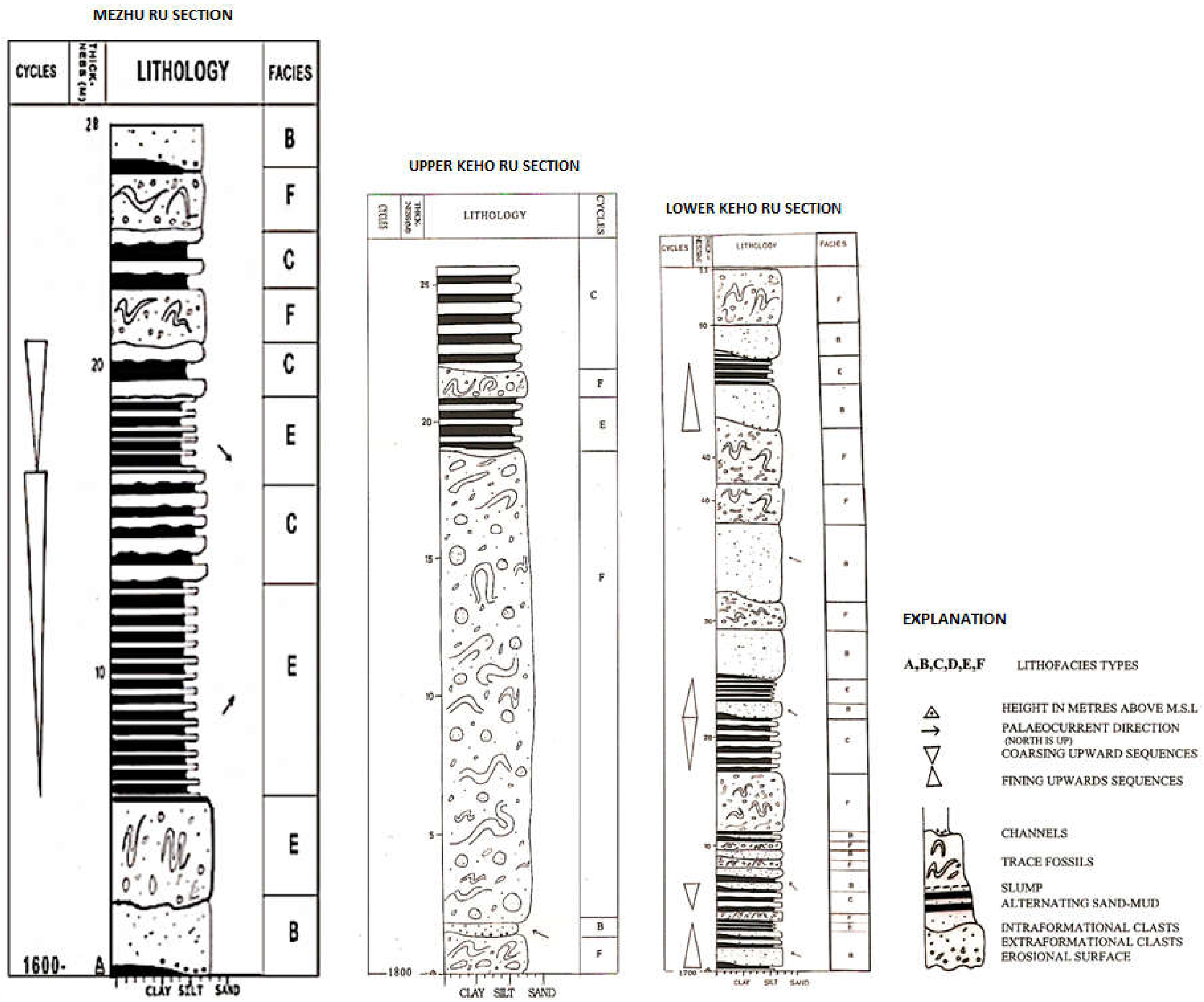

Fig. 3

Plate 1.1

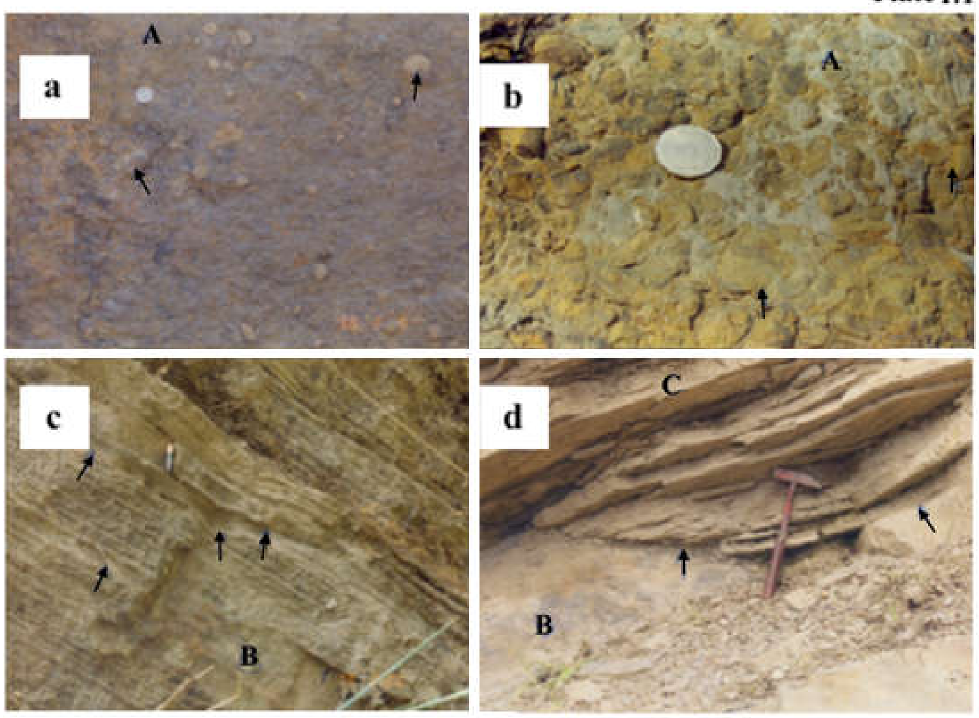

Plate 1.2

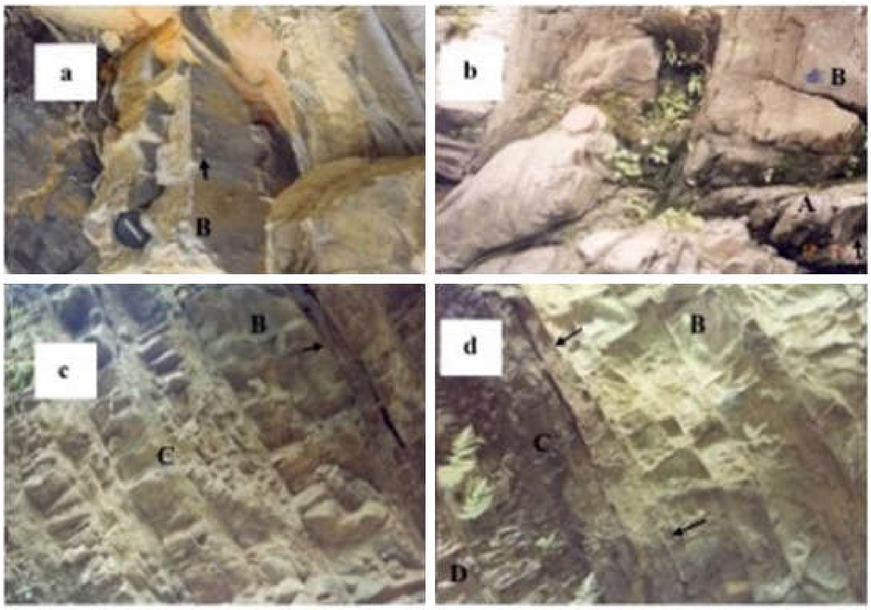

Plate 1.3

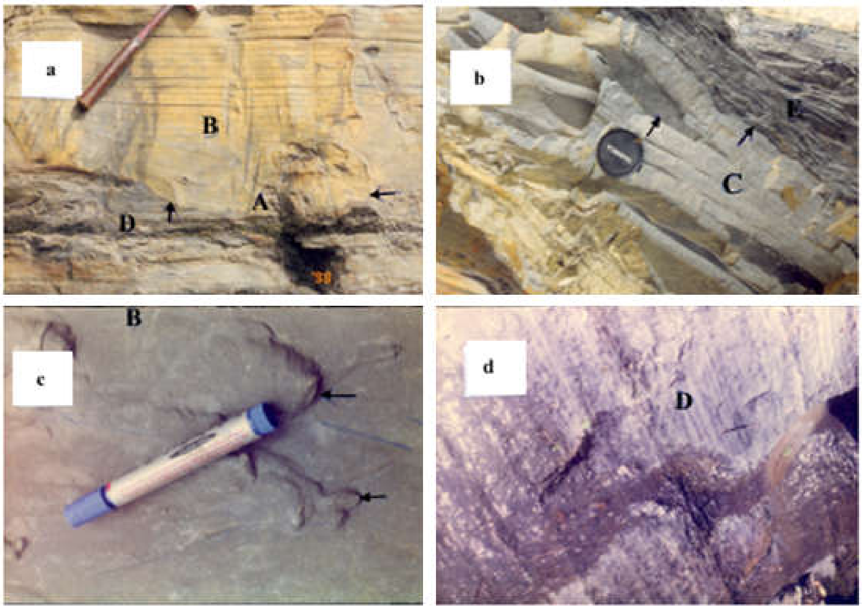

Plate 1.4

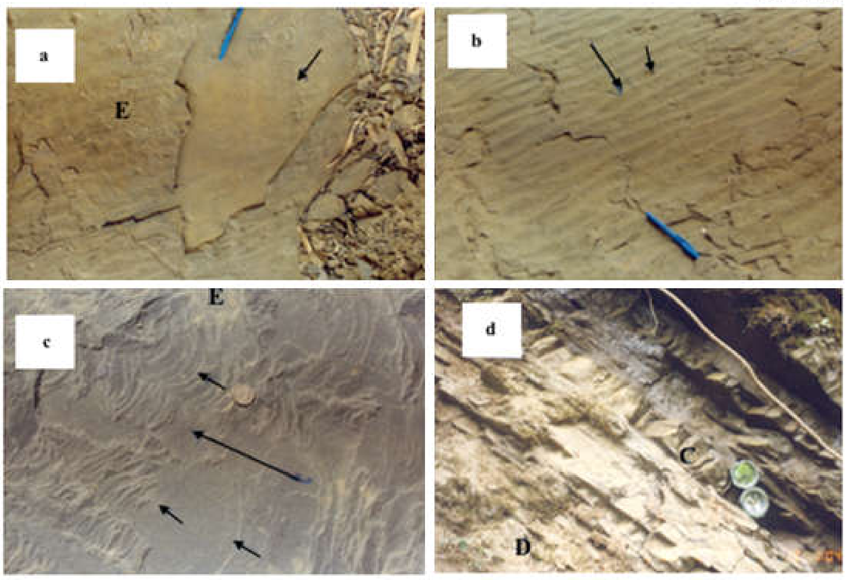

Plate 1.5

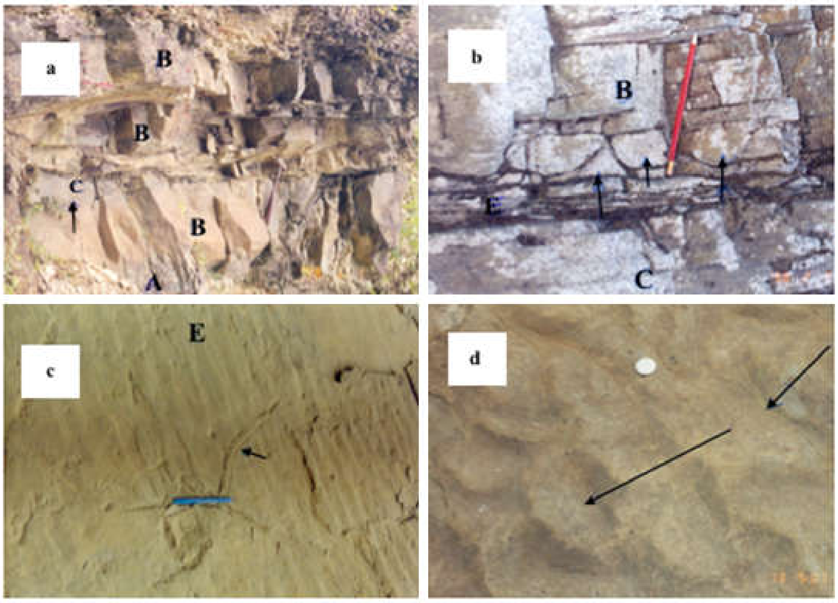

Plate 1.6

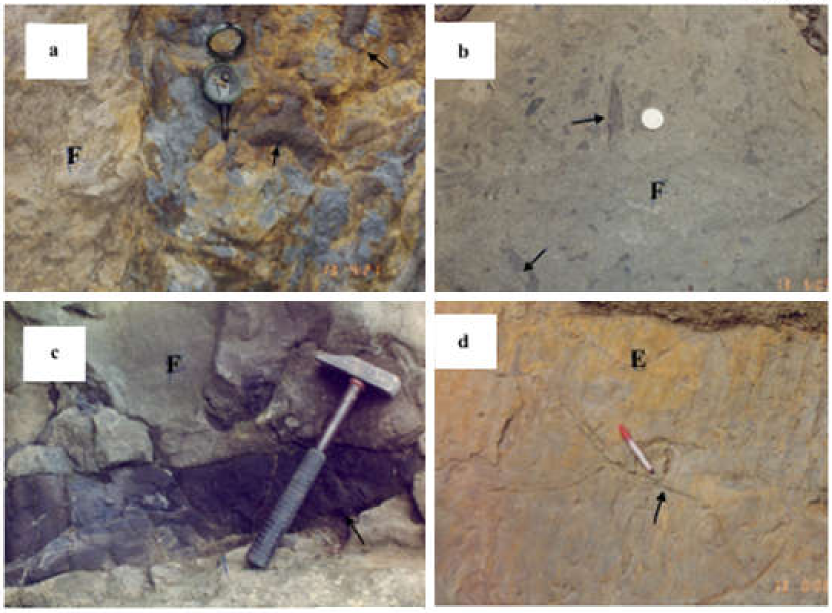

Plate 1.7

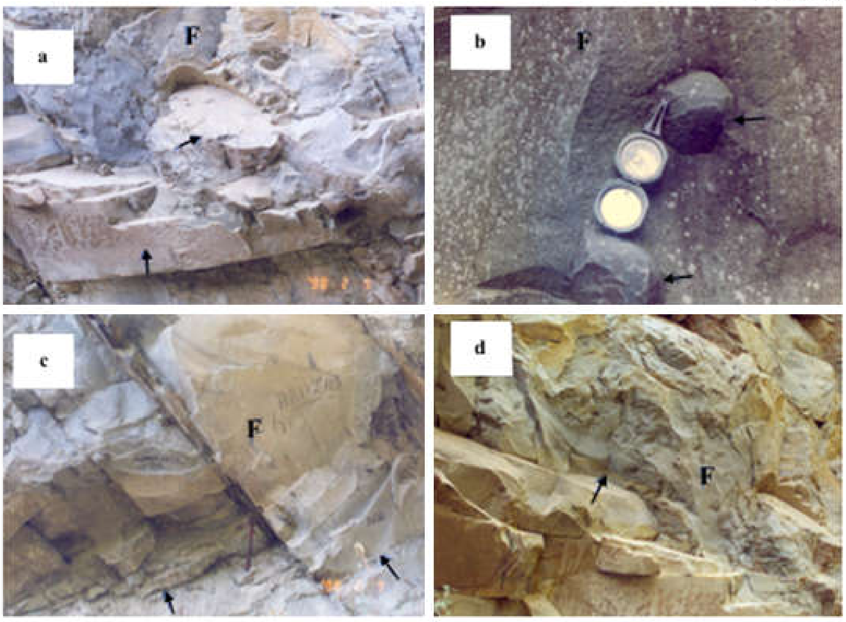

Plate 1.8

ii) Fine to very fine grained, thickly bedded lenticular sand bodies showing sporadic faint plane /low angle characterize shallow distributary channels in the submarine mid fan. This lithofacies is assigned with code 'B'. The base of the lithofacies 'B' is either channeled or faint gradational especially when it overlies lithofacies 'A'. Beds do not possess conspicuous grading and occasionally show fluid escape structures like dish structure.

iii) Fine grained massive graded sandstone beds interbedded with mud rocks occupy usually the top of coarsening and thickening upward sequences. To some extent sandstones bodies resembles with those of Bouma Division 'A' (Shanmugam, 1997) and has been identified as lithofacies 'C'. Small scale shallow channels are common. The facies has been assigned with outer fan turbidity current deposit.

iv) Thin fine laterally persistent sandstone interbedded with substantial proportion of shale resemble classic turbidites of distal type. They show incomplete Bouma sequences generally beginning with 'B' or 'C'. The lithofacies which has been assigned with the code 'D' matches with those of submarine outer fan deposits.

v) Thinly bedded fine to very fine grained sandstone interbedded with substantial proportion of shale characterize over bank deposits in the inner and middle submarine fan. Many sandstone beds are massive and lens out laterally. Spectacularly preserved ripples and ripple cross laminations are characteristic to this lithofacies 'E'. Its common association with the debrites is remarkable.

vi) Channel structures preserved through out the succession do not show any sign of lateral accretion.

Depositional History

The entire assemblage of characteristic sedimentary features of different lithofacies of the Palaeogene Disang–Barail Transitional Sequence of the study area suggests a deep sea sequence where submarine fan deposits are overlain by lower slope-apron accumulations. In other words, deposition of DBTS took place in different parts of the submarine fan under the influence of tectonic impulses active at that time. This tectonic phase in the history of Indo-Burman ranges (IBR) has been characterized by a board open transgressive epiric sea located along the passive margin. During early Middle-Eocene period there occurred a collision of Naga-Chin-Arakan Island Arc, located towards east west within the oceanic domain of India and Myanmar with the central Burmese (Myanmar) continental block (Acharyya, 1990). The signature of tectonic impulses was recorded in the abducting ophiolitic complex together with fluctuations in the sea level. The sedimentation in the deeper as well as shallower parts of the sea kept pace with tectonism and the on-going Eocene-Oligocene sedimentation continued uninterrupted in parts of the Assam-Bengal basin, and west of Naga-Chin-Arakan Island Arc. Naik (1998) visualized this tectonic phase as phase of retrogradation leading to the soft collision of north eastern edge of the Indian plate with the Sinian plate changing the northerly part of the eastern passive margin of India into a collisional belt. The heterolithic nature of the Palaeogene sediments clearly indicate that their contained detritals have not been derived exclusively either from passive, active or collisional orogen rather they indicate towards a transitional tectonic regime (Mack, 1984). The sedimentation rate in the depositional basin was increased during this period, perhaps due to the increased rate of unroofing of the source terrene leading to excessive supply of lithic fragment populations. Significant volumes seem to have been transported to the depositional site by deep sea channel systems across continental slope and in turn virtually the flat basin floors (Carter, 1988). The fluctuations in the water level caused due to flickering tectonic impulses led to erosion and filling of channels by turbidity currents and developed meandering / braided courses. The tectonic impulses appear to have triggered debris flow in the slope aprons which ultimately reached to the base of the slopes and were resedimented on top of the submarine fan deposits. Turbidity currents seem to have been generated in the sedimentary gravity flows and ultimately giving rise to different types of lithofacies in different parts of the submarine fan.

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