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DEPOSITIONAL MECHANISM OF THE PALAEOGENE SEDIMENTS AT DISANG-BARAIL TRANSITION, N-W OF KOHIMA, NAGALAND, INDIA

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ABSTRACT

The Palaeogene Disang- Barail Transitional Sequences (DBTS) preserved in parts of Naga Hills, Northwest of Kohima, Nagaland, present a distinctive lithology comprising sand- silt- mud alternations. Sedimentological studies employing grain-size and facies analyses techniques have been attempted to understand the depositional mechanism of DBTS. Altogether four lithofacies types, namely Bioturbated mud facies, Coarse silt- very fine sand facies, Fine to medium sand- mud facies and Very fine to fine sand facies have been identified and interpreted in terms of processes. The study of grain-size parameters reveals that the siliciclastic of the study area are coarse silt to medium-sand, well to moderately well-sorted, fine to coarse skewed and meso-to-leptokurtic in character. Palaeocurrent patterns indicate a centripetal type of dispersal pattern. A near-shore shallow marine depositional environment with fluctuating energy conditions has been envisaged for the deposition of DBTS.

Key words: Palaeogene, Disang-Barail Transitional sequence, Depositional mechanism, Kohima

INTRODUCTION

Amongst Palaeogene sequences preserved in parts of Naga Hills, there occurs a distinctive lithology which liaise gradationally the underlying monotonous Disang shales (Upper Cretaceous - Middle Eocene) with the overlying multistoried Barail sandstones (Oligocene). It is an approximately 80m thick succession of heterogeneous lithology comprising sand-silt-mud alternations that has been designated as Disang- Barail Transitional Sequences (DBTS, Pandey and Srivastava, 1998, Srivastava, 2002). In the present investigation an attempt has been made to study the sedimentological attributes of DBTS, employing grain-size and litho-facies analyses.

It is an established fact that the grain size of clastic sediments relate to the physical characteristics of the depositional environments, especially the dynamic forces operating during deposition (Wentworth, 1922; Krumbein and Pettijohn, 1938; Visher, 1969, 1970; Tucker and Vacher, 1980; McLaren, 1981; Forrest and Clark, 1989 and Sahu, 1964, 1983). Nevertheless, discrimination among ancient depositional environment based on grain-size parameters suffers from limitations such as diagenetic changes and subsequent modifications which framework particles undergo (Ghosh and Chatterjee, 1994). Thus, the study of other sedimentological parameters, such as sedimentary structures and their associations, palaeocurrents, geometry, fossil content, etc becomes necessary; in conjugation with the grain-size analysis; for a better understanding of the depositional environments, as they rely more on the processes that were operating upon at the time of deposition of the sediments (Reading, 1986).

GEOLOGY OF THE AREA

According to Mathur and Evans (1964), the Cenozoic rocks of Nagaland are disposed from east to west into three distinct morphotectonic units comprising the Naga Hills, namely the Ophiolite belt, the Inner fold belt and the Schuppen belt respectively. While in the schuppen belt, barring Disang sediments, all other litho-stratigraphic units, viz. Barail, Surma, Tipam, Dupitila and Dihing Groups are represented in their original stratigraphic order in different thrusted blocks, the Disang and Barail Groups with the intervening DBTS are the only lithologies developed in the Inner fold belt.

The present area of investigation (fig.1) forms a part of the Inner Fold Belt and displays a succession of heterogeneous lithology characteristic of DBTS (Pandey and Srivastava, 1998; Srivastava and Pandey, 2001). The DBTS overlies gradationally the monotonous argillaceous sediments of Disang Group and in turn passes upwards into the arenaceous sediments of Barail Group (Table-1).

Table 1: Lithostratigraphy of the Study Area.

Sequence	Lithology	Age (Tentative)	Reference
Barail Group	Sandstones with minor Shale.	Oligocene	Krishnan, 1982
Disang- Barail Transitional Sequences (DBTS)	Sand, Silt and Shale alternations.	Upper Eocene	Pandey and Srivastava, 1998
Disang Group	Shales with minor Sandstones.	Upper Cretaceous to Middle Eocene	Krishnan, 1982

LITHOFACIES AND THEIR DISTRIBUTION

Meticulous measurement and recording of lithologic variability in time and space has proved as a sensitive tool in understanding the depositional environment of sedimentary sequences. Comprehensive systematic considerations to such studies have been provided by Le Blank (1972), Selly (1976), Reineck and Singh (1980), and Reading (1986). Accordingly, in the present investigation an attempt has been made to study

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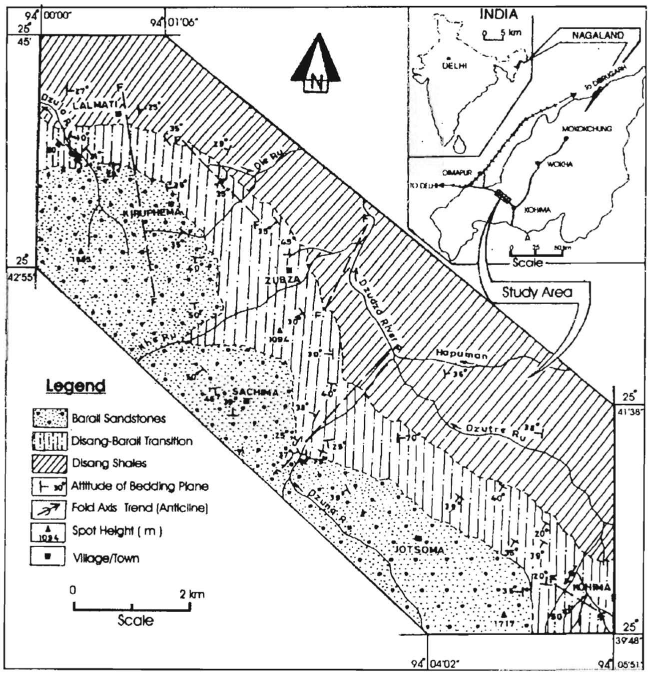

Fig. 1. Geological map of the study area.

the lithologic variability within the DBTS using facies analysis. Based on the different parameters including lithology, sedimentary structures, palaeocurrents, geometry and trace fossils; altogether four lithofacies have been identified and designated as Bioturbated mud facies, Coarse silt-very fine sand facies, Fine to medium sand-mud facies and Very fine-to-fine sand facies. In general, an overall coarsening and thickening upward sequence; with occasional preservation of fining and thinning upward cycles; characterizes the DBTS of the study area.

Bioturbated Mud facies: This facies is characterized by clay and fine silt size particles, moderate to strong bioturbation and associated mottling effect. Thickness of the facies varies from 1.5m to 20.16m. It constitutes approximately 18% of the total sections measured. It is well developed in the northern part of the study area. However, sporadic occurrence in other parts of the area is also not very uncommon.

Coarse silt-very fine sand facies: This facies possesses micro hummocky cross stratification along with sole marks developed in coarse silt to very fine sand layers which can be traced laterally for tens of meters. On an average it constitutes 6% of the total sections measured and varies in thickness from 0.15 to 0.32 meter. It usually occurs as ribbon shaped bodies in association with bioturbated mud facies.

Fine to Medium sand-mud facies: This facies is characterized by alternations of fine to medium sandstones and carbonaceous shale along with coal lenses/ streaks, small scale current ripples & cross beddings, scour and fill structures as well as erosional surfaces lined with mud clasts. At places horizontal bedding showing colour differences were also recorded. It constitutes nearly 28% of the total section measured. This facies is well developed as linear or shoestring type bodies in the southern part of the area.

Very fine to fine sand facies: This facies comprises of very fine to fine sand and parallel and low angle laminated sand layers with occasional pebble lag and burrow structures. The thickness of facies varies from 1.5 to 15 m in which individual unit ranges in thickness from 0.30 m to 1.5 m. A little over 48 % of the study area is represented by this facies. This facies is very well developed in the central part of the area.

GRAIN SIZE ANALYSIS

Grain size measurements of 35 siliciclastic samples were carried out using conventional thin section method. More than 250 grains in each thin section were measured. The grain size data thus obtained were grouped in to half phi (ϕ) intervals and were used for constructing cumulative curves. Different percentiles were obtained from cumulative curves and used in calculating various statistical parameters (Table 2) following Folk and Ward (1957).

Statistical parameters and their spatial variations: The graphic and moment measures not only reflect the environment of deposition but also found helpful in deciphering hydraulic conditions of transporting medium and depositional basin (Mc Laren and Bowels, 1985; Ghosh and Chatterjee, 1994). In the present study graphic measures have been preferred to moment measures because the former is simpler to calculate and generally independent of inaccuracies introduced by truncating and grouping of data (Jequet and Varnet, 1976; Swan *et al.*, 1978).

Distribution of mean size (4.7 to1.76 ϕ) in DBTS presents an overall increasing trend towards the southern part of the study area. Besides, a gradual improvement in sorting (0.236-0.38ϕ) from western (moderately well sorted) to eastern (well sorted) part of the area has also been noticed. Near symmetrical to coarse skewed (-0.477 to 0.29ϕ) sediments dominate the western part whereas fine skewed sediments characterize the eastern part of the area. In general, meso- to leptokurtic distributions predominate the area. The overall variations in the grain size parameters are being attributed to the fluctuating energy conditions of the depositional basin.

Bivariate plots: Bivariate plots employing different combinations of statistical parameters have been successfully used to discriminate depositional environments of the modern sedimentary deposits. These plots in turn pave the way to understand the depositional environments of ancient deposits. Accordingly, in the present study an attempt has been made to interpret depositional environments of the DBTS using the plots (figs. 2, 3 & 4) of graphic skewness versus graphic

Table 2: Representative data on statistical parameters of the Palaeogene sediments of DBTS, NW of Kohima, Nagaland.

Sample no.	Φ_{50}	Mean size (Mz)	Standard Deviation (σ_I)	Simple sorting measure (So_S)	Skewness (Sk_I)	Simple Skewness measure (α s)	Kurtosis (K_G)
R98/199	4.7	4.7	0.236	0.45	-0.166	-0.30	1.84
R96/18	3.5	3.5	0.507	0.85	0.290	0.10	1.16
R97/58	1.7	1.7	0.365	0.35	0.188	0.30	0.99
R97/56	2.3	2.2	0.562	0.95	0.214	-0.30	0.97
R97/173	2.5	2.4	0.380	0.73	-0.212	0.30	0.81
R97/183	2.1	2.1	0.466	0.55	-0.055	0.20	1.09
R96/12	3.7	3.7	0.452	0.75	0.088	0.10	1.22
R97/129	4.5	4.4	0.396	0.65	-0.317	-0.50	0.88
R98/200	4.3	4.5	0.366	0.55	-0.477	-0.50	0.90
R96/14	4.3	4.2	0.577	0.80	-0.170	-0.40	0.93
R96/1	3.4	3.3	0.547	0.90	-0.045	0.00	1.05
R96/40	4.3	4.2	0.437	0.70	-0.233	-0.40	0.95
R97/140	3.6	3.6	0.467	0.80	0.055	-0.10	1.09
R98/205	3.5	3.5	0.430	0.70	0.126	0.20	0.95
R97/64	1.9	1.8	0.482	0.85	-0.084	0.30	1.16
R97/73	3.0	3.0	0.492	0.80	0.000	0.00	1.09

standard deviation (Friedman, 1961), graphic mean versus graphic skewness (Stewart, 1958; Friedman, 1961; Moila and Weiser, 1968) and simple skewness measure versus simple sorting measure (Friedman and Sanders, 1978). An overall beach environment is indicated for the deposition of sediments. Further, the shape of C-M pattern (fig. 5) after Passega (1957, 1964) reflects transportation of detritus under graded suspension.

Discriminant function Analyses: Discriminant function analyses (linear and multigroup) after Sahu (1964, 1983) were used for further discrimination among depositional environments. An overall shallow marine environment is indicated by Linear discriminant function analysis, while multigroup discriminant function analysis points towards a near shore- shallow marine environment (figs. 6, 7).

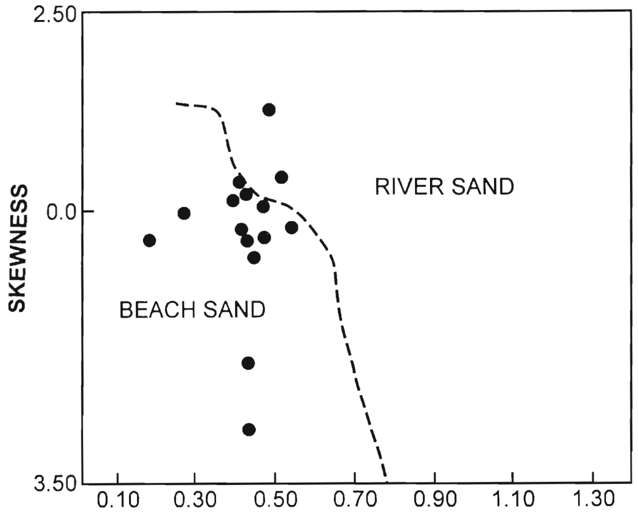

Fig. 2. Bivariate plot of Skewness versus Standard deviation indicating a beach environment for DBTS.

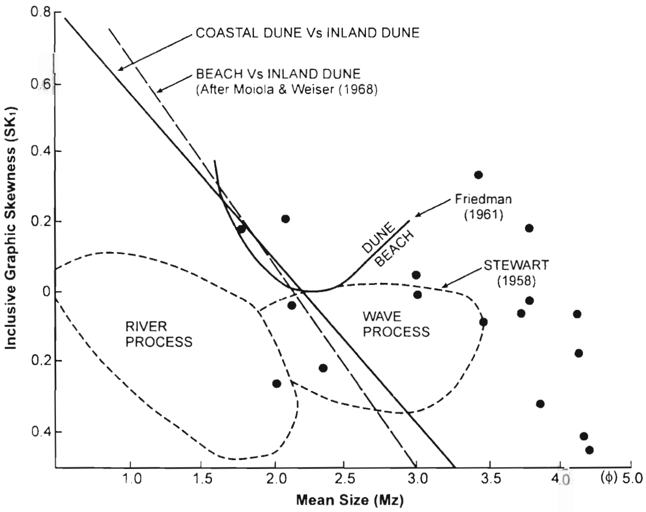

Fig. 3. Bivariate plot of Skewness versus Mean size indicating mixed environment and wave process for the deposition of DBTS.

PALAEOCURRENTS

During recent years, increasing attentions have been paid to reconstruct palaeo-flow and dispersal pattern of siliciclastic rocks on the basis of systematic measurements of both directional as well as scalar quantities (Potter and Pettijhon, 1977). In order to understand the palaeo-flow and the dispersal pattern of sediments in the study area, systematic mapping of grain size variations and proportions of sand -mud have been employed following the method suggested by Potter and Pettijhon (1977). Directional structures, wherever encountered, were also utilized to infer the palaeocurrent directions.

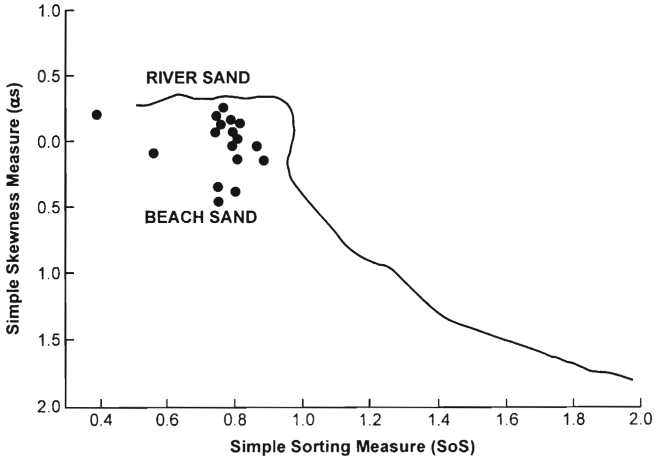

Fig. 4. Bivariate plot of Simple Skewness measure versus Simple Sorting measure showing beach environment for DBTS.

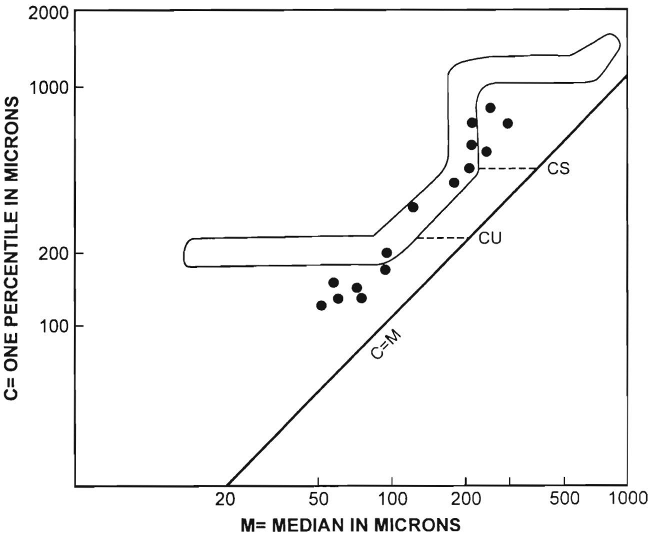

Fig. 5. C-M pattern for DBTS indicating graded suspension load.

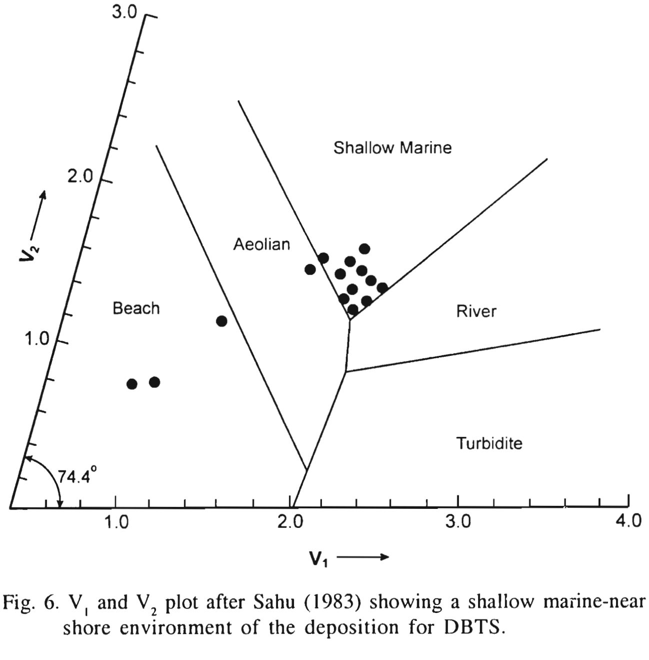

Fig. 6. V_1 and V_2 plot after Sahu (1983) showing a shallow marine-near shore environment of the deposition for DBTS.

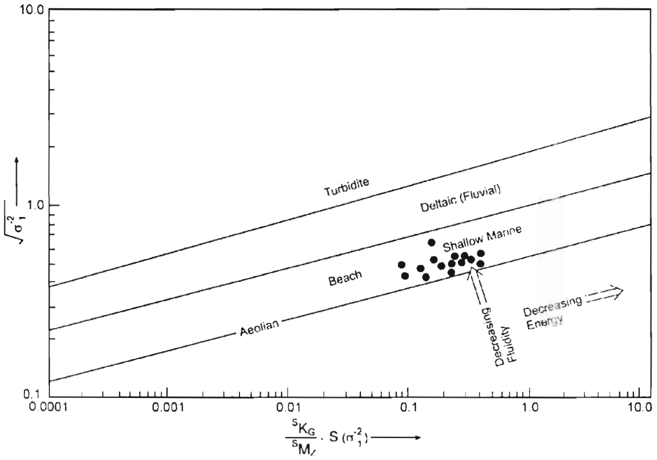

Fig. 7. Log-Log plot after Sahu, (1964); indicating a shallow marine depositional environment for DBTS.

Study of the palaeocurrent patterns in the area points towards a centripetal type of dispersal pattern. Aerial variations of mean size indicate gradual decrease in the competency of transport medium from SSE to NNW in the western part, SW to NE in the central part and SE to NW in the eastern part of the study area. Decreasing sand- mud ratio in conformity of the directions inferred as well as the flow directions measured from some of the directional structures including small scale asymmetrical ripples, small and medium scale cross stratification and a few channel structures further substantiate the above observation. It seems quite likely that sediments were fed from different directions under a fluctuating energy regime of the depositional basin.

DISCUSSION

The common associations of bioturbated mud and coarse silt-very fine sand facies indicate genetically related sub-environments. Togetherness of moderate to strong bioturbation and micro-hummocky cross stratification points towards recurrence of fair weather and an eventful weather, possibly a storm (Harms *et al.*, 1975), respectively. During the storm phase the wave base penetrated deeper down the water column causing distal part of the basin to experience sudden increase in the rate of sediment transport leading retention of sediments into suspension till the waning of the storm (Ghosh and Chattarjee, 1994). This is followed by deposition and reworking of deposited material during fair weather condition. Thin ribbons of coarse silt to very fine sand in association with highly bioturbated mud, thus, represent storm and fair weather phases respectively.

Intercalation of fine to medium sand - mud, in which sandstones generally display small to medium scale cross stratification besides being moderately bioturbated, characterizes offshore transition zone (Elliott, 1986). Presence of coal streaks, carbonaceous mud, ripple lamination, scour and fill structures as well as erosional surfaces lined with mud clasts and well developed horizontal bedding/ parallel lamination further substantiates an offshore transition. On the other hand, linear or shoestring, very fine to fine sand facies displaying parallel and low angle lamination with occasional pebble lag and burrows of *Ophiomorpha* sp. appears to have been deposited in the upper shore face (Leeder, 1982).

The hydraulic processes that seem to have controlled the sediment dispersal patterns during the deposition of DBTS, are **i)** net westward current related to easterly winds accompanying frequent storms, **ii)** onshore directional wave surges having increasing intensity with decreasing water depth (Curray, 1960), and **iii)** net offshore suspension transport of silt and silt-enriched-mud derived from coastal areas perhaps through tidal inlets. In general, the hydraulic regime may be considered as storm dominated, as the processes controlling sediment erosion and transportation are largely related to storms. Analysis of the textural parameters in the study area clearly indicates a progressive basinward decrease in the mean grain size, degree of sediment sorting and also sand-mud ratio. This observation, coupled with lithofacies distribution in the area is interpreted as reflecting a progressive decrease in the energy across the shelf in response to increasing water depth and decreasing intensity of wave disturbances resulting in a texturally graded shelf setting (Johnson and Baldwin, 1986).

CONCLUSIONS

The study on depositional mechanism of the Palaeogene sediments at Disang-Barail Transition, NW of Kohima, Nagaland, using lithofacies and grain size parameters, suggests that the sediments were transported from different directions to the depositional site dominantly through suspension mechanism and ultimately deposited in a near shore-shallow marine environment under the influence of a fluctuating energy regime. Variations in textural parameters reflect energy variability across the shelf leading to mixing of different size populations. The study further suggests that the lithofacies distribution of DBTS has largely been controlled by storm and fair weather processes.

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