FACIES ASSOCIATIONS IN THE LOWER BIMA FORMATION IN ZAMBUK AREA, NORTHERN BENUE TROUGH

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ABSTRACT

Section logging and measurements of the Lower Bima Formation in the Northern Benue Trough was undertaken with the aim of deciphering the various lithofacies and deduce the most probable palaeoenvironments of deposition. This was achieved by recognition and division of various lithological units and characterizing their genetic relation. Four major lithofacies units have been recognized. These are the Grain supported Granulestone, Silty Clay, Planar cross-bedded Sandstone and the Trough cross-bedded Sandstone, occurring within a fining upward couplet. These have been interpreted to signify various subsets of a braided river system.

KEYWORDS: Logging, Lower Bima, Lithofacies, Palaeoenvironments, Braided River

INTRODUCTION

A Facies association consists of a group of facies genetically related to one another in such a manner as to have an environmental significance (Dike, 1972). Facies associations are routinely used in determinining the palaeoenvironment of deposition of studied sections on the basis of relevant changes in depositional processes within a depositional system (Miall, 1996; Orton and Reading, 1993). The recognition of lithofacies associations is therefore an important part of facies analysis, as it is most commonly the associations which provide the clue to the environment of deposition (Reading and Levell, 1996). The associations provide additional evidence which makes environmental interpretation, particularly in the elimination of the alternative interpretations, easier than treating each facies in isolation. Facies associations are thus, the essential building blocks of facies analysis.

In the northern part of the Benue Trough to which the study area belong (Fig. 1), the Cenomanian is marked by the mainly fluviatile sediments as represented by the Bima Sandstone. This syn- rift sequence has not been adequately dated due to the general lack of body fossils. However, reports by the consultants of the NNPC (Robertson, 1989), based on palynology, suggest late Albian to early Turonian age.

The Bima Sandstone outcrops in the Bornu sub-basin and the Northern Benue Trough with reduced thickness along the Zambuk Ridge, a subsurface uplift of the Basement Complex (Samaila, 2007). Its thickness is about 3000m in the Upper Benue Trough according to Carter *et al* (1963). Lithologically, it is composed of gravelly to medium grained, poorly sorted and highly feldspathic sediments. The Bima Sandstone rests on the crystalline Basement Complex and consists of three component members: lower (B1), Middle (B2) and an Upper (B3).

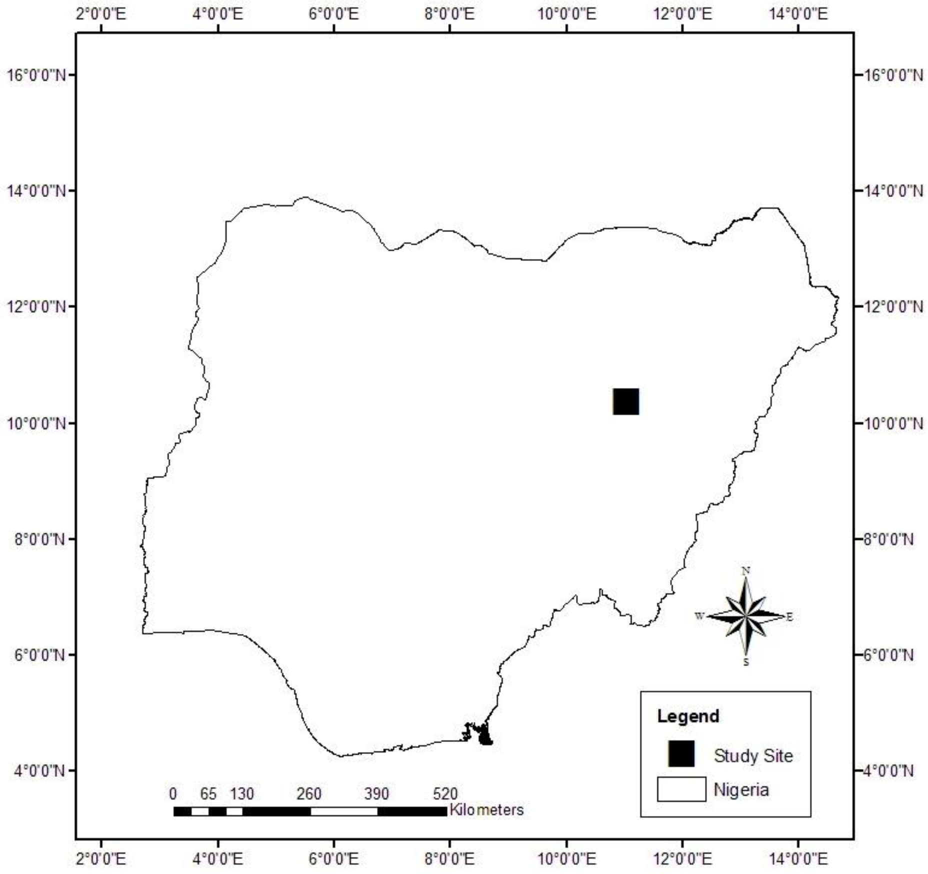

Figure 1: Map of Nigeria showing the location of section

Avbovbo *et al* (1986) believe that these members are distinct, mappable depositional entities that should be accorded new formational status. They were then designated as "Pre Bima" Formation. However, the interpretations of the Kinasar 1 well by Dike and Bature (1999) and Dike (2002a) suggest that the Middle Bima (B2) rests on the basement and in most of the basin, the Lower Bima member (B1) may not be present.

MATERIALS AND METHODS

Reconnaissance

Reconnaissance survey was used as an aid to locate suitable section for the field studies and also to determine the accessibility of the study area by locating foot paths. The Nigerian Federal Survey topographic map sheet was used. This phase was undertaken during the raining season. Access to the site achieved using foot paths and truck routes to reach the section which was subsequently earmarked for detailed sedimentological logging.

Section measurement and description

This exercise was aimed at studying the outcrop section in detail by measuring and recording all features of geologic interest such as strikes and dips, sedimentary structures and the azimuths of directional structures. Logging of each section was based on recognition and subdivision of lithologic units such as clay, silt, sand and granulestone. This follows the style of Tucker, (2003). After identification of the lithologies, bed thicknesses were measured using convetional mapping equipment and details of the attributes were recorded in the field note book. In addition, dips and strikes were determined using compass clinometers; the azimuth was determined using Brutton compass. Systematic collection of outcrop samples of the Bima Formation was undertaken for each stratigraphic horizon using soft rock hammer.

RESULTS

Section Description

At the base of the section (Fig. 2) is the matrix supported granulestone, poorly sorted without internal stratification overlain by grey coloured, compositionally kaolinitic silty clay which is about 0.38m thick. These form a fining upward trend. Another cycle began with the deposition of grain supported granulestone which grades into a medium to coarse grained trough cross-bedded sandstone which is subsequently overlain by the grey coloured clay with silt, the top of which is marked by an erosion surface. The cycles are capped by moderately sorted, planar cross-bedded sandstone, the lower one being interspersed with thin parallel clay beds.

Lithofacies Recognition

Planar cross- bedded sandstone lithofacies

This is encountered at two horizons (Figs. 2 and 3) and characterized by foresets mostly at high angles to bedding planes. Also characterized by mud in slough, it may signify formation by successive slack and dominant current stages and that its formation began when current is of high velocity and charged with sediments eroded by current stage. This lithofacies is mostly fine grained. This sandstone is predominantly an arkosic arenite with minor proportion of subarkose and lithic subarkose. Mineralogically, quartz and feldspar are the dominant mineral constituents with plutonic and metarmophic fragments of rock forming a minor percentage.

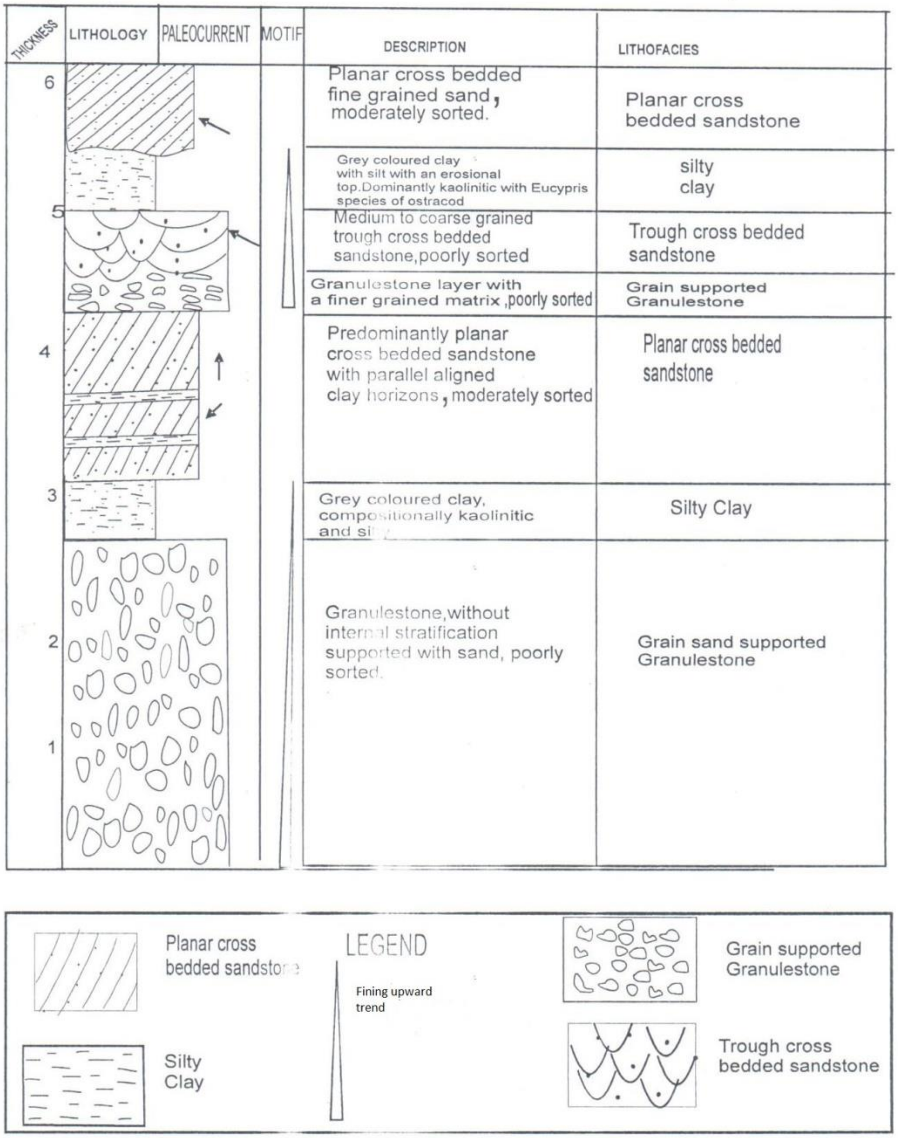

Figure 2: Lithology of a section of the Lower Bima Formation at Zambuk

Trough cross-bedded sandstone lithofacies

This lithofacies has a restricted occurrence, observed only towards the top of section (Fig 2,3) It is characterized by well defined trough cross-beds. Quartz, K- feldspar and rock fragments are the major constituents. Others are the iron oxides and scattered bands of heavy minerals. This lithofacies occurs within a fining- upward profile in association with channel lag deposit as observed and reported by Cant and Walker (1978) for the modern Saskatchewan braided river. The trough cross- beds, with curved bounding surfaces were generated by forward migration of 3- dimensional linguoid bars (Ricchi – Lucchi, 1995). Although trough cross-bedding may form in different environments ranging from fluvial to aeolian to transitional environments (Tucker, 2003), this lithofacies is here interpreted as a deposit of braided river in channel. This is buttressed perhaps by the absence of bioturbations, typical of marine and lacustrine facies.

Silty Clay lithofacies

This lithofacies was also recognized at two levels. This facies exhibits an eroded top, terminating the upper cycle (Fig 2) The colour is generally gray, though various shades ranging from light to dark were also noted. Mineralogically, it is dominated by kaolinite and its samples yielded the ostracod species of *Eucypris* sp. and *Cypridopsis* sp. The silty clay lithofacies is here interpreted as a deposit of flood plain which had been preserved. It is composed of both kaolinitic as well as marine related clay minerals such as montmorillonite and illite and the absence of primary bedding features imply the involvement of weak currents.

Matrix supported granulestone lithofacies

Lithologically, this facies type appears to be relatively simple. It is encountered at the base of the section (Fig 3). It consists in most parts of granule sized particles interspersed within a finer grained matrix. This lithofacies also has a quartz dominanted mineralogy with K- feldspar forming a significant proportion.

DISCUSSIONS

The section represents a strong flood during a peak period resulting in the deposition of the Granulestone. This lithofacies with interspersed pebbles of quartz appear to be deposited by fast streams (Allen, 1965) and may represent fluviatile channel flood deposit of braided stream (Doeglas, 1962). Thus, it could represent a debris flood deposit in probably a braided river setting, the cyclic nature of lithofacies suggesting a Donjek type (Miall, 1977). Debris flood deposits are not peculiar to braided river settings but may also be found in the distal part of an alluvial fan. It has been observed (Bull, 1963) that this type of deposit may exhibit vertical pattern of larger clasts as a result of the matrix. Debris flood deposits occur during flash floods which occur when an environment experiences sudden dump of rain in large amounts in a limited area (Prothero and schwab, 2004).Cycles formed by flood deposits are usually less than a few metres thick and fine upwards. Because of the high energy flood waters, with accompanying deposition of very coarse to gravelly deposits, fossils and organic matter, which are rarely present, readily gets destroyed. Accordingly, the matrix supported granulestone fits into the characteristics outlined.

Though Walker and Cant (1986) has observed that fine sediments are rarely deposited by braided river systems, during major floods rivers may spill over to deposit some fines.

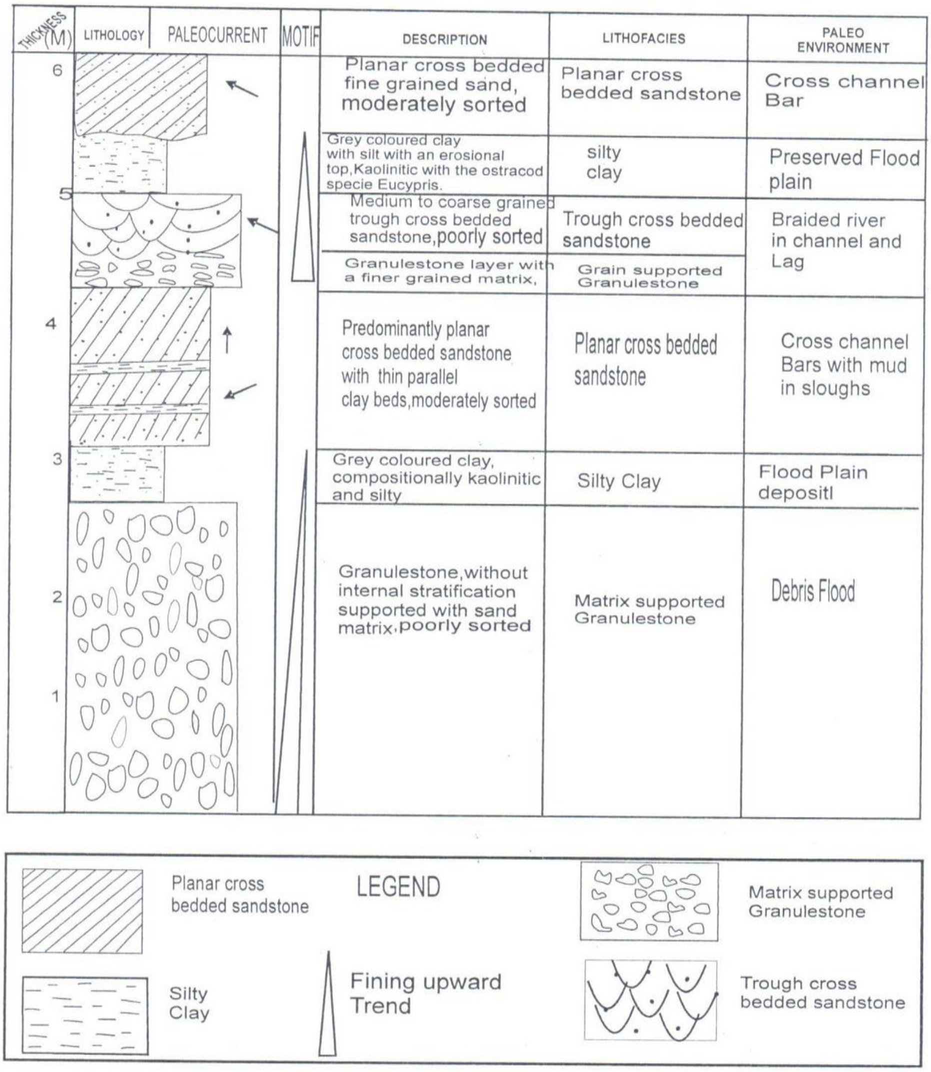

Figure 3: Lithostratigraphy and palaeoenvironmental interpretation of a section of the Lower Bima Formation at Zambuk.

Such fines may again be eroded due to channel migration. As strength decreases and falls below the critical competence needed for transport, the silty clay lithofacies settled as flood plain deposit.

Subsequent fluctuations of current led to formation of thick planar crossbedded sandstone with mud in sloughs as cross channel bars. These sands form during periods of low to moderate discharge when channels are relatively wide and shallow (Cant and walker, 1978) most sandy braided rivers have tabular bars, either linguoid or straight crested (Smith,1970).

A renewed cycle of increased flow velocity deposited an in channel confined deposit of medium to coarse grained trough cross bedded sandstone with lag at its base. This is overlain by the silty clay lithofacies with same features as highlighted earlier. However, it contains the ostracod specie *Eucypris*. Capping both cycles in the section is the planar cross-bedded sandstone.

CONCLUSION

A section of the Lower Bima Formation studied in Zambuk area of the Northern part of the Benue Trough revealed the presence of four major units of lithofacies. The grain supported granulestone, The Silty Clay, The planar Cross-bedded Sandstone, and the Trough cross-bedded Sandstone. These constitute a fining upward trend. Analysis and interpretation of the sequences have suggested various subsets of a mainly braided river built upon deposits of an alluvial fan system.

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