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FIELD AND SEDIMENTOLOGICAL STUDIES OF THE AJALI SANDSTONE FROM A ROAD-CUT ALONG FUGAR-AGENEBODE EXPRESSWAY, EDO STATE, SOUTHERN NIGERIA; IMPLICATIONS FOR MATURITY, FACIES AND PALEODEPOSITIONAL ENVIRONMENT

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ABSTRACT.

Field and sedimentological studies of exposed sections along the Fugar-Agenebode road-cut was carried out with the purpose of defining the facies, analyzing the paleocurrent, establishing the textural and mineralogical maturity of the sandstone and inferring the environment of deposition. These involved logging the road-cut and making a ternary plot with thirty strike values recorded on the field. It also involved laboratory studies to determine the mineralogical composition of the Sandstone. The Ajali sandstone is whitish, friable and cross bedded. The sandstone is overlained by a considerably thick deposit of red lateritic soil in many of the places it outcrops. The sandstones are composed mainly of medium to coarse grains with pebbly base. The grain shapes vary from subangular-subrounded. The angularity or roundness of the grains is a measure of the nearness or how far the sediments have been transported from the source area. The paleocurrent analysis of the crossbeds showed a NE-SW-NW trend, indicating the source area and direction of the river that transported the sediments which formed the sandstone. A microscopic examination of the mineralogical composition of the sandstone revealed that the constituent minerals were quartz (92%), feldspar (3%), rock fragments and mica (5%). The ternary diagram plot indicated that the sandstone variety was quartz arenite, indicating that it is mineralogically and texturally mature. The sedimentary structures observed were crossbeddings (planar and tabular) as well as herringbone crossbedding. These structures are diagnostic of a tidal environment.

Keywords: Sedimentology; Ajali Sandstone; Mineralogy; Texture; Paleocurrent; Sedimentary Structures.

INTRODUCTION

The field is where rocks occur in their natural form. The relative positions, local and regional geologic setting of features can be captured on the field. Similarly, readings of features/structures in-situ and representative samples can be collected on the field for further laboratory studies (Adaikpoh, 2009).

Sedimentology is the scientific study of sedimentary rocks and of the processes by which they were formed; the description, classification, origin and interpretation of sediments (Gary *et al*., 1974). It is akin to working backwards from the products which are known to inferring the processes which are unknown. According to Wolff and Benedict, 1964, sedimentology involves the five fundamental processes; weathering, erosion, transportation, deposition and diagenesis.

Sandstone is a clastic sedimentary rock that forms from sand-size sediments. The particle size ranges from 0.0625mm to 2mm in diameter. They are abundant on the earth's surface and are among the

important clastic rocks as a result of their characteristic porosity and permeability. These properties make sandstones good aquifers for groundwater and excellent reservoirs for petroleum.

Sandstones are made up of minerals such as quartz, feldspar, rock fragments and mica. It also contains heavy minerals, usually less than 1% in composition (Pettijohn, 1987).

Structures formed in sedimentary rocks are very useful in paleocurrent analysis. They are indicative of environment of deposition. The paleocurrent analysis involves measurement of the orientation of key sedimentary structures formed during transport of sediment by moving fluid. It provides direct information about the orientation of the sedimentary systems. The paleocurrent analysis also gives useful information on the source area and ancient paleoslope.

Field and sedimentological studies of the exposed sections along Fugar-Agenebode road cut was carried out with the purpose of defining the facies, analyzing the paleocurrent and establishing the textural and mineralogical maturity of the sandstone.

GEOLOGICAL SETTING

Anambra Basin is a major inland sedimentary basin in Nigeria. Its evolution was based on the theory of the separation of the African and South American plates during the Middle Mesozoic period (Burke and Duratoye, 1972; Nwachukwu, 1972). The theory of Anambra Basin ascertains that it contains Albian-Santonian sediments in the eastern half referred to as Abakaliki depression while the other half proto-Anambra was platform consisting of Post-Santonian sediments (Murat, 1972; Nwachukwu, 1972).

STRATIGRAPHY

The filling of the Anambra basin took place in the time interval of End Santonian to Early Paleocene. There was one major marine transgression, the Nkporo transgression that initiated deposit in capping off deposition in the basin. Stratigraphic packaging is thus conveniently into two - the Nkporo Group and the Coal measures. The Nkporo group is so called because the Nkporo shale has several lateral equivalents. The lithostratigraphic units in the Anambra Basin are shown in table 1 below. The facies of most the Nkporo Group once inferred to be pro-delta to delta front environment (Ladipo, 1987). The shaly aspect of the group with their mixed arenaceous and planktonic Foraminiferas suites represents the pro-delta facies of the Campano-Maastrichtian marine incursion. The Enugu shale is interpreted to be formed as in the delta flood plains (over bank sheet floods, swaps and channels (Agagu, 1978).

Table 1: Lithostratigraphic units of the Anambra Basin (Nwajide, 2005)

Age	Basin	Stratigraphic Units							
Thanetian	Niger Delta	Imo Formation							
Danian									
Maastrichtan	Anambra Basin	Coal Measures	Nsukka Fm						
			Ajalli Fm						
			Mamu Fm						
Campanian		Nkporo Fm	Nkporo Shale	Enugu Fm	Owelli Ss	Afikpo Ss	Otobi Ss	Lafia Ss	
Santonian	Southern Benue Trough	Awgu Fm							

The Mamu Formation most probably documents a delta strand plan with thickly vegetated tidal mud flat which resulted in coal seams (Agagu *et al*., 1985).

The overlying Ajali Formation has been attributed to fluid deposited (Agagu and Ekweozor, 1982; Nwajide and Hoque, 1982) and to the development of shallow marine subtidal sand bars (Ladipo 1986).

The Nsukka Formation is upper Maastrichitan to Danian (Ladipo, 1987). The lithology is similar to that of Mamu Formation. It consists of distinct assemblage of sandstone, shale, mudstone and sandy-shale with coal seems present at various horizons.

STUDY AREA

The Fugar-Agenebode road cut is located 44km North-East of Auchi in Etsako West Local Government Area of Edo state, Southern Nigeria. It lies geographically between latitude $07^0$5''30' and longitude $06^0$32''37' at an elevation of 186m. The area is surrounded by Lokoja to the North, Benin to the West, Warri to the South and Makurdi to the North-East. (Figure 1)

Relief, Climate and Vegetation

The general topography of the study area is characterized by steep slopes, ridges and valleys. Soil is lateritic in nature. The vegetation at the time of the field trip was mainly grasses, shrubs, low bushes sparsely distributed with occasional concentration of dense forest vegetation along river banks. The major crops are cashew, plantain, groundnut, pineapple, yam, banana and cassava. The climatic condition in this area is of tropical type with the annual alteration of dry and wet seasons. The area was generally dry and dusty as at the time of the field trip.

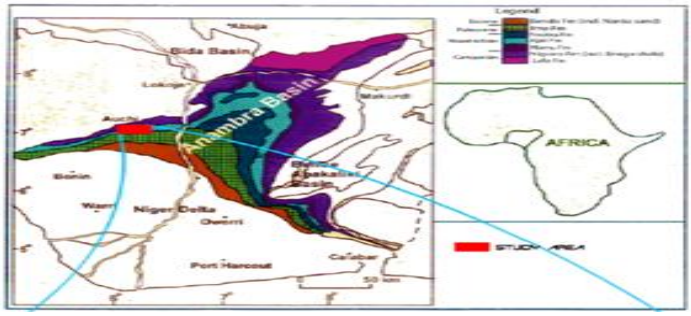

Figure 1. Map showing the Anambra Basin and other Basins in Southern Nigeria. Study area is indicated in red (After Geological Society of Nigeria, 1994)

MATERIALS AND METHODS

The study involved both field and laboratory studies.

Field Studies

The field study involved field mapping exercise covering the area under study. This included a detailed lithostratigraphy profile of the road cut, noting the textural

features (such as grain size, grain shape, sorting), colour, and sedimentary structures present. The field work was carried out on December 12, 2020. Samples were collected at suitable intervals or units of the outcrop by scraping off weathered surface to expose fresh surfaces in each unit of the outcrop with the aid of geologic hammer. Stratigraphic logging from bottom to top of the outcrop was carried out and recorded.

Paleocurrent Analysis: Thirty strike values were measured of the cross beds that were conspicuous on the sandstone. The readings were taken with the aid of the compass clinometre to ascertain the direction of current when the sediments were being deposited. The ternary plotter software was used for the rose current diagram.

Laboratory Studies

Mineralogical Maturity: A microscopic examination of the mineralogical constituents of the sandstone was carried out. This is based on the framework composition of the grains that make the sandstone. This revealed the mineralogical composition of the sandstone to be quartz (92%), feldspar (3%), rock fragments and mica (5). The result was used to plot a ternary diagram to ascertain the variety of the sandstone and its maturity mineralogically.

DISCUSSION OF RESULTS

The sequence from top to bottom is given thus; thick deposit of red lateritic soil which caps the sandstone, whitish , cross bedded sandstone in the middle and thin ferrogunized sandstone at the base.

The grain sizes are mainly of medium-coarse grained with pebbly base. The grain sizes were moderately to poorly sorted. Grain shapes are subangular to subrounded. A distinct feature of the sandstone is the absence of clay, suggesting that it is mineralogically and texturally matured as also confirmed by the ternary diagram analysis.

The grains are friable (non-cemented) and the colour varies from milky to whitish. Sedimentary structures were cross beddings (angular ad planar) and herringbone crossbedding. It is also characterized by bioturbated beds which are as a result of disturbances by animals such as worms. The array of sedimentary structures, especially the bi-directional herringbone crossbeddings are indicative of periodic reversals of tidal current directions. The environment of deposition is therefore of tidal origin.

A detailed field description of the sandstone was carried out by logging a vertical section, as presented in figure 2

UNIT/DEPTH (cm)	DESCRIPTION
620	Cross bedded sandstone, medium grained. Whitish in colour
585	Massive sandstone. No structure observed. Medium to fine grained
540	Coarse grained sandstone, sorting is poor. Yellow brown colour resulting from weathering
510	Massive, fine to medium grained. Whitish in colour
430	Massive, fine to medium grained. Whitish in colour. Poorly sorted
395	Fine to medium grained. Whitish in colour. Well sorted. Cross bedded
321	Fine grained, whitish, cross bedded but not as prominent as in other units
280	Cross bedded sandstone, fine grained. Whitish in colour. Well sorted
240	Cross bedded sandstone, medium to fine grained. Whitish in colour. Moderately sorted
205	Fine grained, well sorted, cross bedded, whitish in colour
170	Medium to coarse grained sandstone, poorly sorted, whitish in colour
75	Medium to fine grained, cross bedded, whitish in colour
Serrated bottom to 25cm	medium to fine grained and massive with no obvious structures

Figure 2: Logged section of the Ajali Sandstone

Paleocurrent

A total of thirty azimuth values were measured on the field. The values were grouped into class intervals and the numbers of strike values that fall within each interval are recorded as the class frequency (Table 2). The class intervals and frequencies were subsequently used in plotting the rose current diagram to reconstruct the ancient current direction.

Table 2 Strike values measured from the crossbeds on the Fugar Sandstone.

CLASS	FREQUENCY
20-40	7
41-60	6
61-80	--
81-100	---
101-120	1
121-140	--
141-160	1
161-180	--
181-200	8
201-240	5
241-260	2

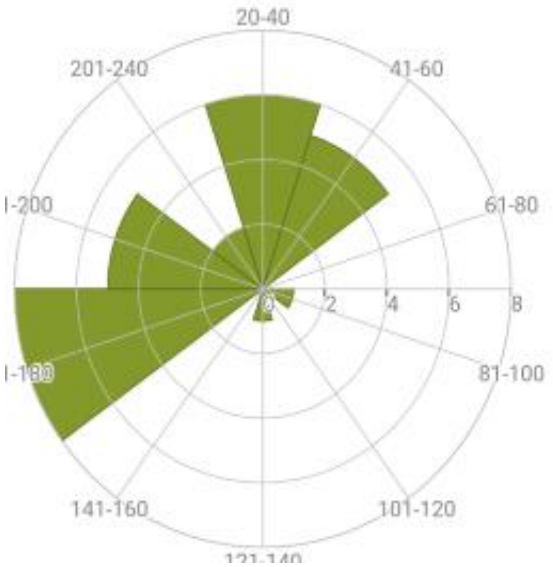

Figure 3: Rose current diagrams showing a NE-SW-NW trend of the crossbeds

The paleocurrent direction shows a NE-SW-NW trend (Figure 3).

Mineralogical Classification of the Sandstone

Table 3 Percentage composition quartz, feldspar, rock fragments and mica in the Ajali Sandstone

QUARTZ	FELDSPAR	ROCK FRAGMENTS AND MICA
92%	3%	5%

The percentage composition of quartz, feldspar, rock fragments and mica is presented in Table 3. When these values were plotted on the ternary diagram, they all fall within the upper edge where there is quartz (Figure 4). This shows clearly that the sandstone is composed mainly of quartz and less of feldspar and rock fragments. Based on the mineralogically classification framework of sandstone by Folk, 1974; using Ternary Diagram, it can be concluded that the sandstone is quartz arenite. It is therefore mineralogically/chemically mature. The gritty feel of the Ajali sandstone as observed on the field can also be attributed to the relative abundance of the mineral, quartz

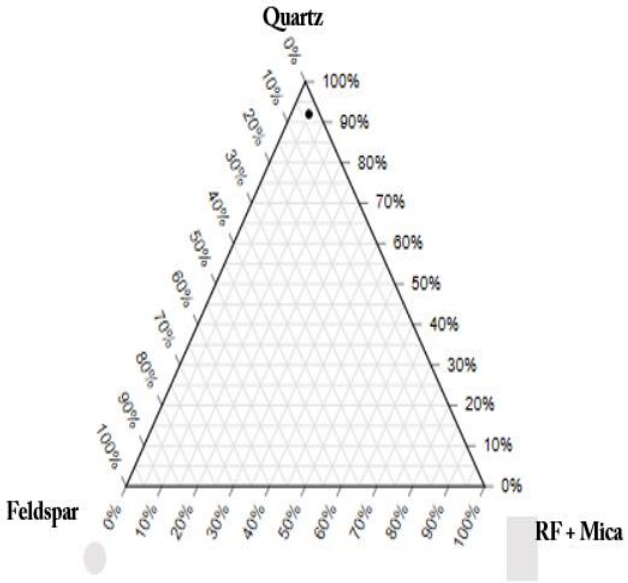

Figure 4. Ternary diagram showing the percentage composition of the Fugar sandstone

CONCLUSION

The sediments in the Fugar locality of the Ajali Formation is made up of three lithofacies; basal massive sandstone, the middle cross bedded and tubular sandstone and the overlying ferruginous sandstone facies. The sandstone is whitish, friable and characterized by the absence of clay. The cross beddings are generally trending in a NE-SW-NW direction indicating the direction of the rivers that brought the sediments. Mineralogically, the grains of the sandstone are mature as indicated by

abundance of quartz. It is therefore classified as quartz arenite.

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