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SEDIMENTOLOGICAL ANALYSIS OF ROCK SAMPLES FROM PARTS OF UGHELLI, NIGER DELTA BASIN, NIGERIA

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Abstract
Eleven rock sediment samples collected from Ughelli in the Niger Delta region were subjected to mechanical grain size analysis and used to analyse for sedimentological properties. The skewness, kurtosis, standard deviation and mean grain size were computed for each of the samples in order to infer the grain size distribution. The mean size (Mz) of the grains ranges from 1.92∅ to 3.10∅, calculated values for standard deviation range from 0.47∅ to 1.77∅ with an average of 0.88∅. The Sedimentological analysis revealed that the sand particles are predominantly fine, poorly sorted to moderately well sorted and very platykurtic. The latter implies that the sediments have been transported over long distances from their source and the former suggests that energy of the environment of deposition was low to moderate.

Keywords: Sedimentology, Sieve Analysis, Grain size Analysis, Niger Delta

INTRODUCTION

Sedimentology involves the study of sediment with the aim of understanding the process that leads to its formation. Sandstone is a major sedimentary rock and is made up predominately of sand grains cemented together (Folk, 1974).

Study of sedimentary structures is important because they are very valuable features for interpreting depositional environment (Folks K.L and Ward, 1957).

The grain size of a soil or sediment refers to the diameter of a particle making up the soil mass. One way of determining the grain size of a soil is by sieving a quantity of the soil through a stack of sieves of progressively smaller mesh openings from top to bottom of the stack. The quantity of soil retained on a given sieve in the stack is termed “one of the grain sizes of the soil sample”. Different statistical parameters can be derived from the cumulative frequency curve gotten from grain size analysis. These include graphic mean, standard deviation, skewness and kurtosis. Grain size analysis is an important method of studying textural characteristics of sediments (Friedman G.M. and Sanders J.E, 1978):

LOCATION OF STUDY AREA

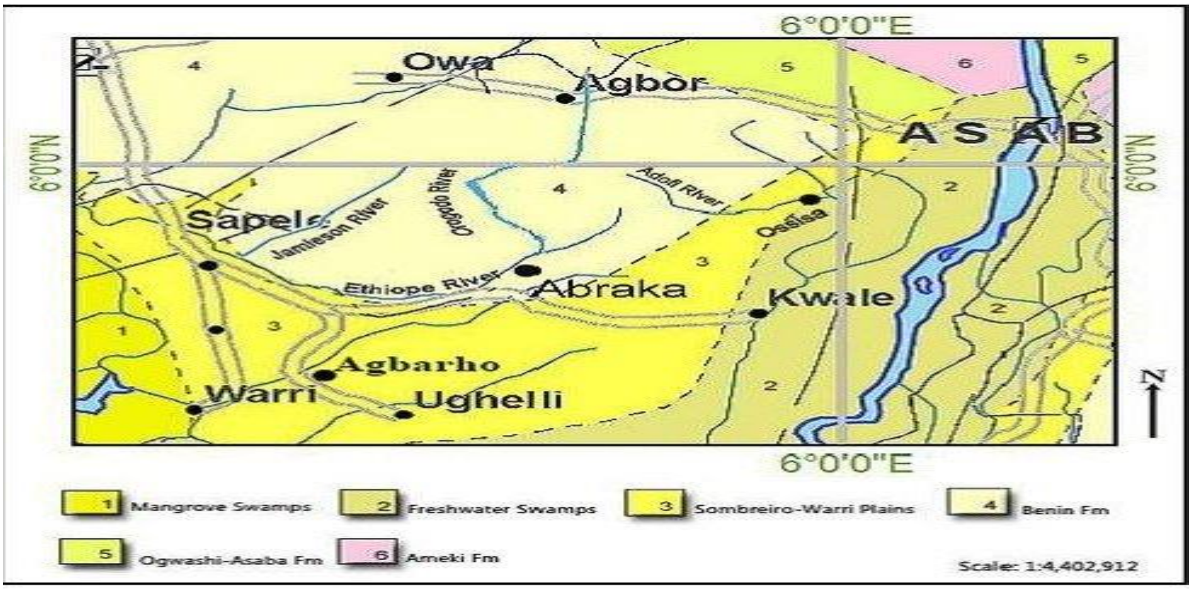


Fig. 1. Geological map of Delta State showing Ughelli - study area –
(After Owoyemi *et al*, 2019)

GEOLOGICAL SETTING

Ughelli is in the sedimentary region of the Niger Delta Basin. The Niger Delta Basin, located in the eastern Gulf of Guinea, is one of the most prolific petroleum basins in the world. The Tertiary section of the Niger Delta is divided into three formations representing prograding deposition facies that are distinguished mostly on the basis of sand-shale ratios. The type section of these formations are described in Short and Stauble (1967) and summarized in a variety of papers (Avbovbo, 1978; Doust and Omatsola, 1990; Kulke, 1995). The Akata Formation at the base is of marine origin and is composed of thick shale sequence (potential source rock), turbidites sand (potential reservoirs in deep water), and minor amounts of clay and silt. Beginning in the Paleocene and through to the Recent, The Akata Formation formed during low stand when terrestrial organic matter and clays were transported to deep water areas characterized by low energy conditions and oxygen deficiency (Stacher, 1995). It is estimated that the formation is up to 7,000 meters thick (Doust and Omatsola, 1990). The formation underlies the entire Niger Delta Basin, and is typically overpressured. Turbidity currents likely deposited deep sea fan sands within the upper Akata Formation during development of the delta (Burke, 1972). Deposition of the overlying Agbada Formation, the major petroleum-bearing unit, began in the Eocene and continues into the Recent. The formation consists of parallic siliciclastics over 3700 meters thick and represents the actual portion of the sequence. The clastics accumulated in delta-front, delta-topset, and fluvio-deltaic environments. In the lower Agbada Formation, shale and sandstone beds were deposited in equal proportion, however, the upper portion is mostly sand with only minor shale interbeds or intercalations.

The Agbada Formation is overlain by the third formation, the Benin Formation, a continental latest Eocene to Recent deposit of alluvial and upper coastal plain sands that are up to 2000 meters thick (Avbovbo, 1978).

MATERIALS AND METHODS

The research work involved both field and laboratory analysis.

Field Sampling: Eleven sediment samples were collected around Ughelli. The samples were collected and put into sample bags which were properly labelled.

Laboratory Grain Size Analysis

The samples were air-dried. All crumps were broken by mashing with a pestle and mixed thoroughly; 50gm of each of the samples was weighed and subjected to granulometric (mechanical) analysis. Mechanical analysis was done by the conventional sieving method using a Tyler shaker and a set of sieves; 600, 400, 250, 160, 112, 90 and 63 microns. The materials required are a set of sieves, a sieve shaker, a weighing balance, a mortar, a pestle and brushes for cleaning the sieves.

Procedure: The screens/sieves/mesh was nested in the order, coarsest at the top with the pan on the bottom. The sample was poured into the top sieve and covered with another pan. The screens were then placed in the shaker, fastened very tightly and sieved for fifteen minutes. Some precautions were taken to ensure accurate results. The samples were allowed to settle down before weighing, there was no air interference while weighing and the set of sieves are arranged in order of decreasing size with the smallest at the bottom and the pan placed below it. Most importantly, the samples are not broken down during disaggregation.

At the end of each sieve, each screen was separately inverted on a sizeable paper and tapped gently with the heel of hand. Tapping was done diagonally to the mesh so that the screen would not be damaged. Finally, each fraction was weighed and recorded. The percentage weight retained and the cumulative weight retained were computed and tabulated. These values were used to plot frequency, histograms and cumulative frequency curves.

CALCULATIONS

The grain size parameters used for this research work was adopted from Folk and Ward 1957).

Mean Size (Mz)

This is a graphic measure for determining the average size of the sediment. It is given by the equation: $Mz = \frac{\emptyset 16 + \emptyset 50 + \emptyset 84}{3}$ ………… Equation 1

Ø16, Ø50, Ø84 are the grain sizes in phi values at which the 16th 50th and 84th percentage lines respectively intersect the cumulative curves.

Standard Deviation (degree of Sorting)

This measures the sorting of the sample. It is given by the formula

$$S.D. = \frac{\emptyset 84 - \emptyset 16}{4} + \frac{\emptyset 95 - \emptyset 5}{6.6}$$ …………… Equation 2

Measurement of sorting values for a large number of sediments has suggested the following classification scale for sorting (Folk and Ward, 1957).

Table 1: Standard measurement values for standard deviation (degree of sorting)

Under 0.35Ø	Very well sorted.
0.35 – 0.50Ø	Well sorted.
0.50 – 0.71Ø	Moderately well sorted.
0.71 – 1.0Ø	Moderately sorted
1.0 – 2.0Ø	Poorly sorted.
2.0 – 4.0Ø	Poorly sorted.
Over 4.0Ø	Extremely sorted.

Skewness (SK_w)

This is a measure of symmetry of the distribution around the mean. A positive (+ve) value shows that the sediment has an excess amount of fines and a negative (-ve) value indicates that it is coarse.

It is given by the equation.

$$SK_1 = \frac{Ø16+Ø84-2Ø50}{2\,(Ø84-Ø16)} + \frac{Ø5+Ø95-2Ø50}{2\,(\varphi95-Ø5)}$$ …………… Equation 3

Kurtosis (K_U).

This is a measure of the peakedness of the distribution and it determines the ratio between sorting of the tail end of the curve and the sorting in the central portion. It is given by the equation.

$$K_G = \frac{Ø95-Ø5}{2.44(Ø75-Ø25)}$$ ………….. Equation 4

If the central portion is better sorted than the tails, the curve is called leptokurtic, if the tails are better sorted than the central portion, the curve is platykurtic. Strongly platykurtic curves are often bimodal with subequal amounts of the two modes.

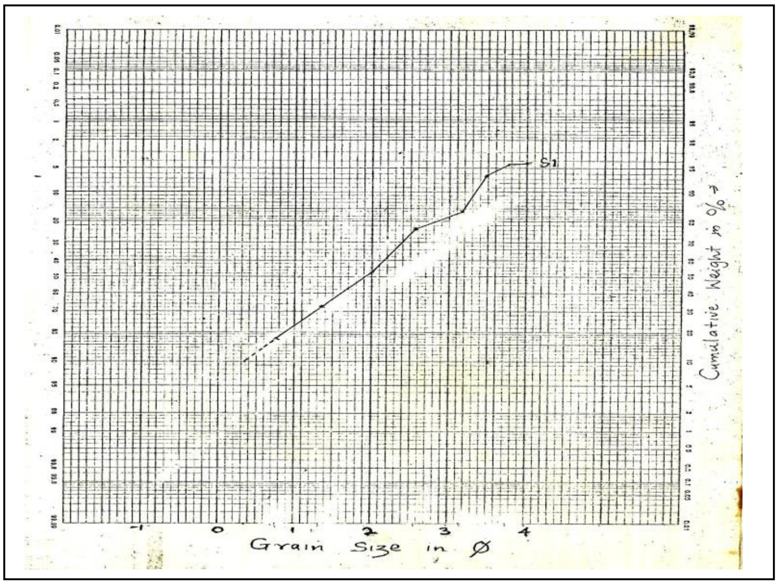
The standard values for the interpretation of kurtosis are shown below;

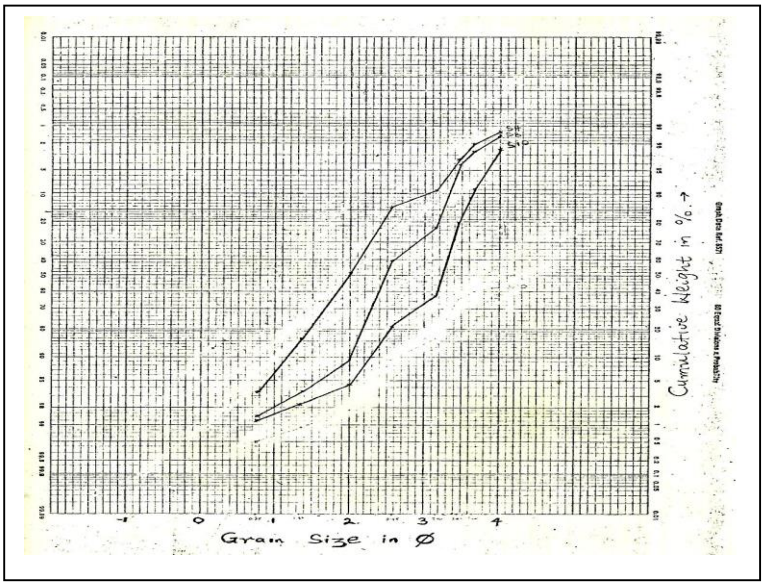
Under 0.67	Very Platykurtic
0.67 – 0.90	Platykurtic
0.90 – 1.11	Mesokurtic
1.11 – 1.50	Leptokurtic
Over 1.50 – 3.00	Very leptokurtic
Over 3.00	Extremely leptokurtic

RESULTS AND INTERPRETATION

Fig. 2: Cummulative frequency curve for sample 1

Fig. 3: Cummulative frequency curves for samples 4, 8 and 10





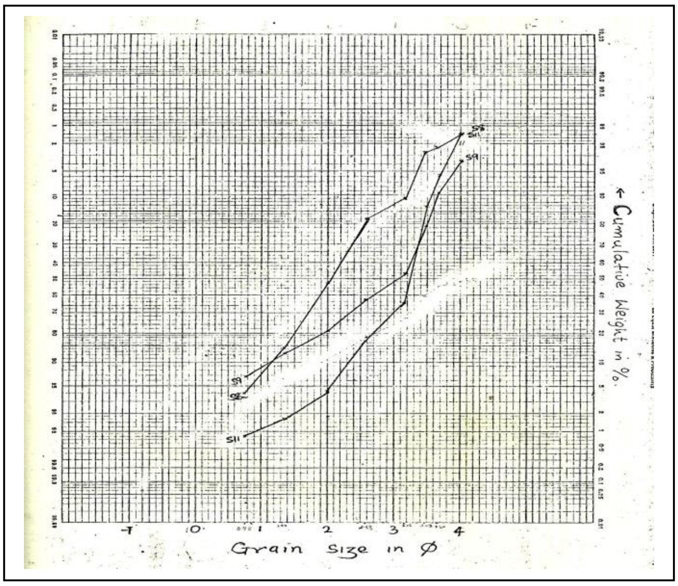


Figure 4.: Cummulative frequency curves for samples 8, 9 and 11

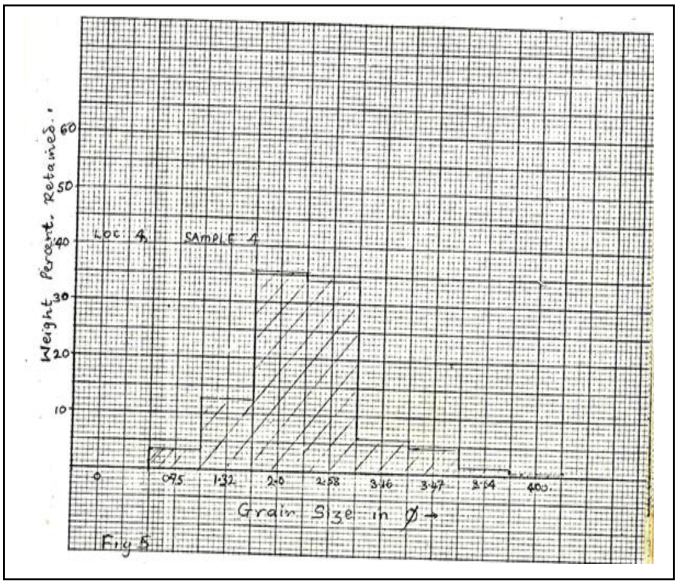


Fig. 6: Histogram for sample 5

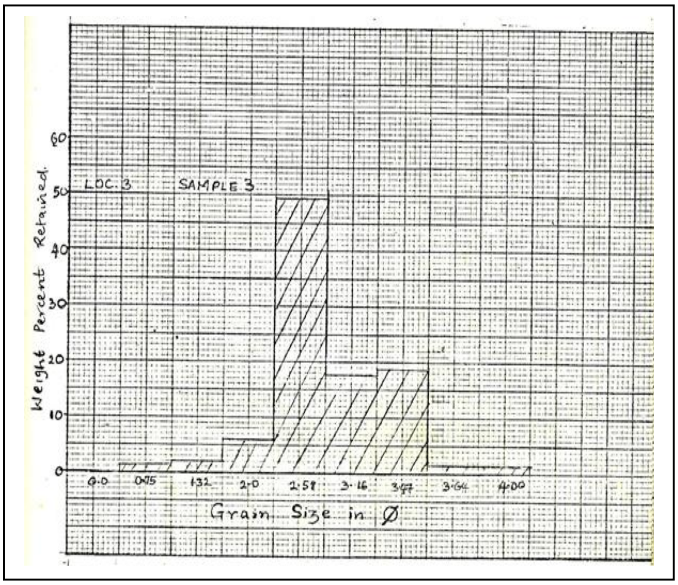


Fig. 5: Histogram for sample 3

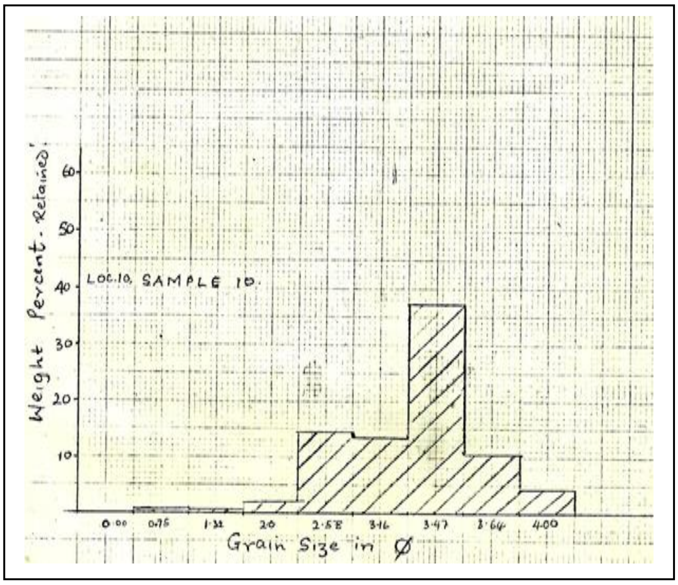


Fig. 7. Histogram for sample 10

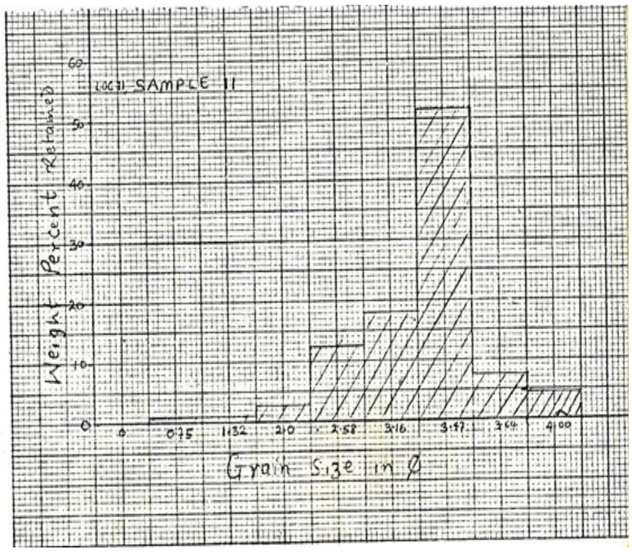


Fig. 8. Histogram for sample 11

Standard Deviation (S.D)

Calculated values range from 0.47Ø to 1.77Ø with an average of 0.88Ø. This implies that the sand is poorly sorted to moderately well sorted. (Folk and Ward,1957).

Kurtosis (KU)

From Table 1, K_G values indicate that all the sand samples are very platykurtic. This implies that the sands have been transported over long distances from their source. It also implies that the source of the sediments is far.

Histograms

These give the percentage of grains in the grade sizes present in the sediment.

Table 2. Grain size distribution showing phi, mean grain size, skewness, kurtosis and standard deviation

Sample	Ø75	Ø5	Ø16	Ø25	Ø50	Ø84	Ø95	M_Z	S.D	SK_W	KU
1	2.58	0.35	0.7	1.10	1.90	3.16	3.65	1.92	1.12	0.03	0.91
3	3.05	1.6	2.45	2.25	2.5	3.25	3.48	2.73	1.77	0.45	0.96
4	2.35	0.92	1.32	1.55	2.00	2.55	3.38	1.95	0.68	0.01	1.26
8	2.45	0.85	1.4	1.59	2.05	2.73	3.35	2.06	0.71	0.03	1.19
9	3.45	1.10	1.70	2.2	3.01	3.55	3.90	2.75	0.88	-0.39	0.91
10	3.32	2.05	2.48	2.72	3.28	3.55	3.85	3.10	0.54	-0.43	1.22
11	3.40	2.05	2.58	2.85	3.25	3.45	3.75	3.09	0.47	-0.47	1.26
						AVERAGE	=	2.51	0.88	-0.11	1.10

INTERPRETATIONS

Mean Size (Mz)

From the calculated values shown in (Table 2), the mean size (Mz) of the grains ranges from 1.92Ø to 3.10Ø. The calculated average is 2.51Ø. This implies that the sand is fine grained (Folk 1957).

Histograms plotted for the samples (Figs 2 – 8) reveal that grains size 2.58Ø has the greatest weight percent of the sands analyzed. This means that it is the dominant grain size. It is followed very closely by grain size 3.44Ø. These values show that the grains are fine (Folk and Ward, 1957).

From the above analyses, it is possible to make the following deductions.

1) Since the grains are poorly sorted to moderately well sorted, it can be inferred that the current was of low to moderately high energy. This indicates an environment a bit far from the shore and also near rivers.
2) The fine nature of the particles indicates that the sands have been transported over very long distances, by currents of low to moderately high energy.

CONCLUSION

From the results of laboratory analyses and field observations, it is deduced that the sand particles are predominantly fine, poorly sorted to moderately well sorted and very platykurtic. The latter implies that the sediments have been transported over long distances from their source and the former implies that energy of the environment of deposition was low to moderate, probably a bit far away from the shore.

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