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Sedimentological Characteristics of Lokoja Sandstone Exposed At Mount Patti, Bida Basin, Nigeria

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ABSTRACT

Basal conglomerate, sandstones, siltstones, and ironstones were the major lithologic units in Mount Patti. They constitute part of the Campanian-Maastrichian Lokoja Formation exposed in the southern Bida Basin of Nigeria. Field Studies and Laboratory analyses were conducted on the sandstone samples to determine the provenance, depositional environment, mineralogical and textural characteristics of the Lokoja sandstone. The Granulometric studies of the deposit are medium to coarse-grained, poorly sorted, dominantly leptokurtic and positively skewed, indicative of river laid sediments. The mean grain size (0.85) suggests medium to high energy depositing stream for the sediments. Morphometric studies of pebbles showed variations in environment of deposition from fluvial to marine settings for the Lokoja sandstone. The scatter plots of maximum projection sphericity index (MPS.I) versus oblate – prolate index (O.P.I.) indicate river origin for the pebbles. The roundness versus elongation ratio (E.R) shows the same fluvial source. The mean roundness value (0.41) reflects angular to subrounded pebbles and short transportation history. Heavy mineral analysis revealed the presence of zircon, rutile, tourmaline, kyanite, sillimanite and opaques indicative of igneous and metamorphic sources, probably the southwest and northcentral Basement Complex terrains. The presence of ironstone, kaolinitic clays, laterite and the heavy mineral suite makes the area economically viable.

Key word: Sandstones, pebble, morphometric, heavy mineral, fluvial provenance.

INTRODUCTION

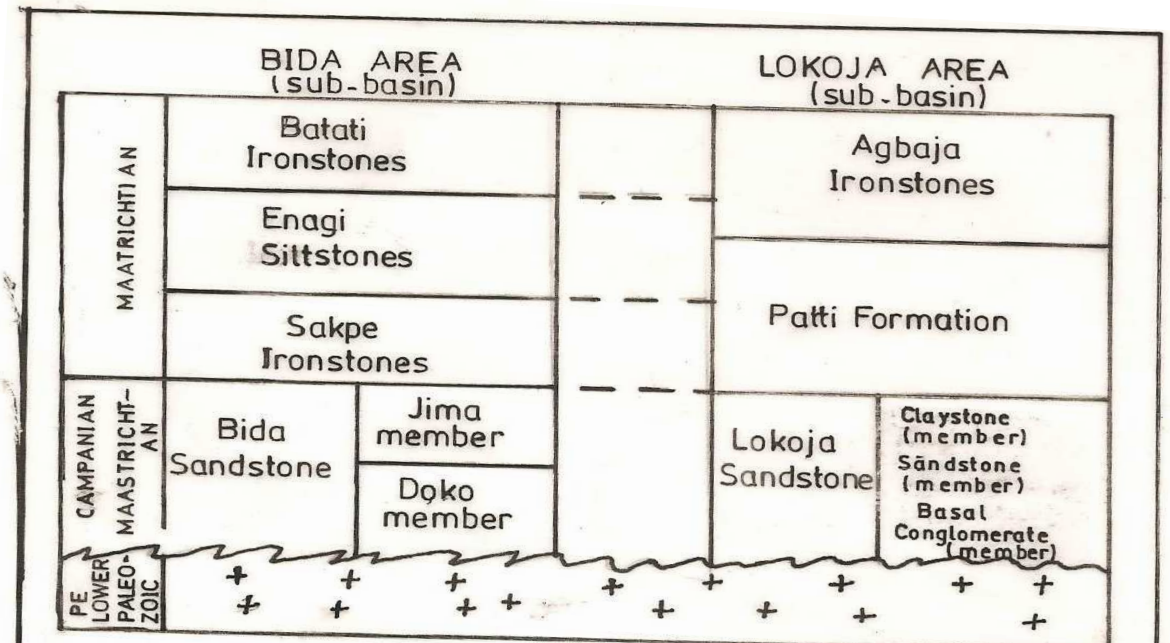
Sedimentological investigation of the Lokoja sandstone employ the granulometric studies of the sandstone and the pebble morphology as aids in deducing the provenance and paleoenvironment of the sandstones.

The study area falls within latitudes $7^{0}48$` - $7^{0}57$`N and longitude $6^{0}42$` - $6^{0}45$`E on Lokoja topographic sheet 247NW. Rocks within Felele, Sarkkin Noma, Karaworo, Nataco, G.R.A and Mount Patti falls within the domain.

Rocks found within Mount Patti belong to the Lokoja Formation, which comprise of conglomerates, massive, pebbly to coarse grained sandstones, claystones, siltstones, ironstones and lateritic capping (Adeleye, 1971, 1973 and Braide 1992). Lokoja sub – basin of the Bida basin is a NW – SE shallow, downwarped trough which resulted from the wrench fault movement associated with the tectonic framework of the Nigerian sedimentary basins (Jones, 1953 and Braide, 1992) which was filled with Campanian – Maastritichian sediments as confirmed by the palaeontological and sedimentological studies (Ojo, 1992, Abimbola 1993). Lokoja sandstone is the oldest formation in the southern Bida basin being 90 – 280m thick, overlain by 70 – 100m thick Maastritichian Patti formation and about 5 – 20m thick of Agbaja Ironstones overlying the middle Patti formation (Braide, 1992, Ladipo 1994).

Mount Patti has been selected as the study area because it represents a typical outcrop and ridge scenarios of the sedimentological characteristic and depositional environment of sandstone facieses from which the mineral potentials of the basin can be reconstructed.

About fifteen outcrop locations were sampled; however, eight representative samples were extensively studied by visual observations and laboratory analyses. Therefore, the results were used to determine the textural and mineralogical characteristics, provenance and the reconstruction of the environment of deposition of the Lokoja sandstone.



F 1 Generalised stratigraphic subdivisions in the Bida basin

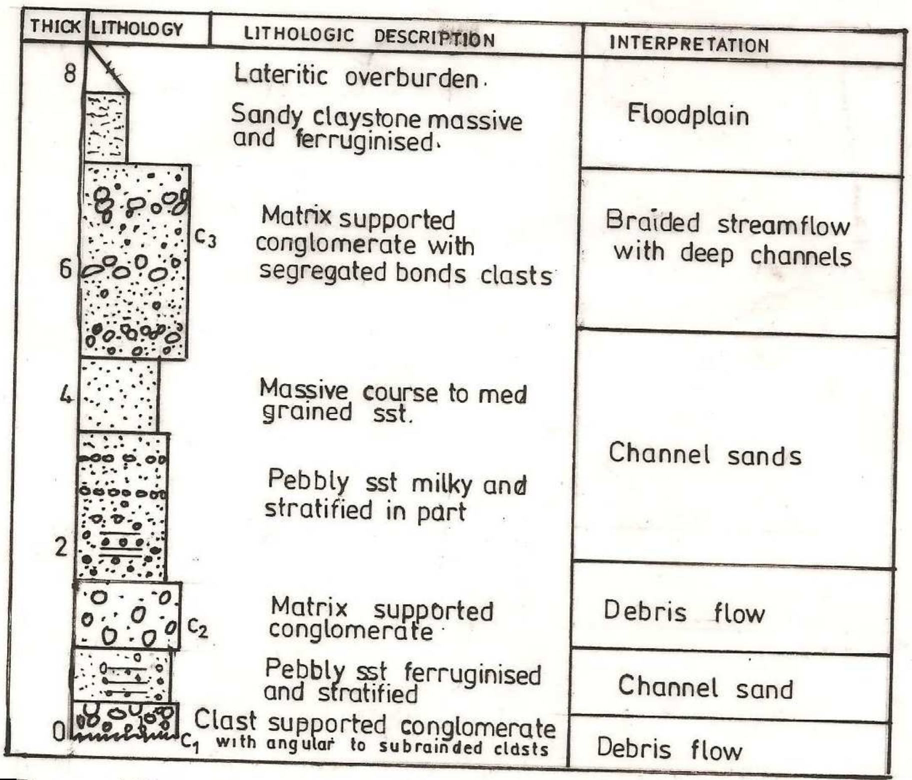


Fig. 2 Lithologic section of the Lokoja Formation at Filele along Okene Abuja Highway.

Stratigraphy

Fig. 1 shows the stratigraphy of the study area, with the Agbaja Ironstone Formation at the top, underlain by the Patti Formation, then the Lokoja Sandstones. The Lokoja sandstone constitute three members; the claystone, sandstone and the basal conglomerate members. Exposures of the Lokoja sandstones were encountered at Filele along Okene-Abuja highway Fig. 2 & Fig. 3 The depositional facies of this geologic unit consist of laterite overburden underlain by claystone, medium grained to coarse grained sandstones and conglomerate. In some places the claystones are ferrugenized. The sedimentary structures range from massive sandstones, stratifications to trough-cross bedding with sharp erosive basal contacts; all reflecting the different depositional environments and conditions of depositions.

Geology and Lithostratigraphic Descriptions

The area of study forms part of the Bida Basin or more appropriately, the Lokoja sub-basins or part of the southern Bida Basin. The Lokoja Sandstone is the basal unit overlying the basement complex unconformably. It is the lateral equivalent of the Bida sandstone, consisting of sub-angular to sub-rounded quartz pebbles in clay matrix. Lithologic units range from conglomerates, coarse to fine grained sandstones, siltstone and claystones, varying in colour from milky to purple and massive to cross-stratified. The prevailing units are generally poorly sorted and composed mainly of quartz and feldspar thus texturally and mineralogically immature (Ojo, 1992).This Formation is exposed between Lokoja and Koton-Karfi and has been interpreted as continental (alluvial fan) deposit (Braide, 1992); the upper part of which have been inundated by marine conditions (Ladipo 1994).Sedimentary structures including cross stratification and biogenic structures are well defined.

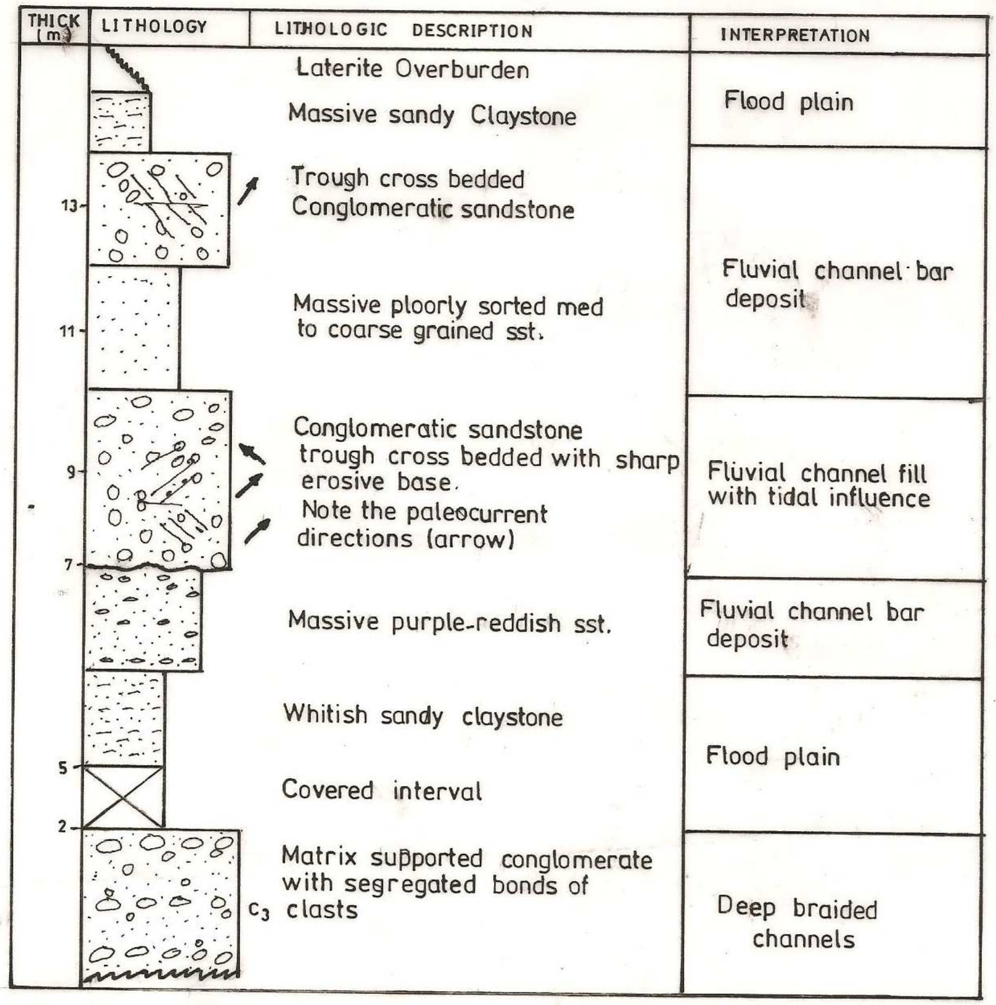


Fig 3 Lithologic section and interpretation of the Lokoja Formation exposed 1.2km north of the Lokoja Market.

A section around the Director General quarters, 1.2km NW of Ganaja junction has a thickness of 11.2m.It is made of matrix supported conglomeritic sandstone with sub-rounded pebbles clast of quartz, feldspar and rock fragments overlying the weathered basement unconformably. The lithology is reddish and ranges from coarse to fine grained texture. At the base of Mount Patti 0.5m from Plaza Hotel is an excavated area showing an exposure of clayey sandstone, medium grain with siliceous cement. Top of it has been weathered intensely by erosion which enriches the basal sandstone overlain by clayey mudstone, pebbly sandstone and lateritic capping. The beds have an average dip magnitude of 10 and stike of S120E.

A road cut section near Filele consists of fining up sequence of conglomerates pebbly sandstones and clay. The basal lithology consists of angular to sub-rounded clasts of matrix supported conglomerates. This grades into a weakly stratified pebbly sandstone and ferrugenized sandstones. About 0.4km north of old market in Karaworo represents a road cut 8m thick. It is a sandy silt unit composed principally of rounded quartz, feldspar and other rock fragments. The lithology ranges from fine to medium grain sandstone, siltstone, matrix supported conglomerates and rounded to sub-rounded quartz pebbles.An exposure at the eastern part of Agricultural Development project(ADP) in Filele is typical of sandy cay unit with interbedded sandstone. Although similar to the earliest exposures but a gross variation in beds thickness resulting from differences in sediments supply and degree of erosion. Alluvial deposits accumulate along the banks of River Niger richly endowed with quartz, feldspar and mica.

MATERIALS AND METHODS

Eight samples of sandstones of varying weights were selected within the study area for the particle size analysis. The grain size analysis was carried out using dry sieving technique. The statistical data on size distribution were obtained and the results used to deduce the mode of transportation and depositional environment of the sediments. The American type of standard sieve (Half – Phi ASTM standard) was employed.

A total of 100 pebbles were picked from the different locations of the pebbly and conglomeratic sandstones within the study area. The analysis involved the measurement of the magnitude of the long axes, intermediate axes and the short axes of the pebbles using Vennier Caliper (Folk, 1980). Thus parameters including the Flatness Ratio (FR) and elongation ratio were obtained (Lutig, 1962). Maximum projection sphericity index (MPSI) (Sneed & Folk 1958), Oblate Prolate index (OPI) (Dubkins and Folk 1970) and Roundness (Sames 1966) were estimated.

Samples of sandstone around the bank of River Niger in Lokoja were analyzed for the heavy minerals. The samples were made into solution in glass cylinder and properly agitated to prevent the particles from adhering to the walls of the separators. After 10mins segregation on density contrast took place. The heavy components were obtained with a dispersion agent added to remove air – bubbles. These were soaked in 30% Hydrogen Peroxide (H_2O_2) solution for total disintegration. Samples were soaked water to wet the particles. The heavy minerals were separated by panning and mounted on the glide slide and observed under the petrological microscope to detect the heavy minerals.

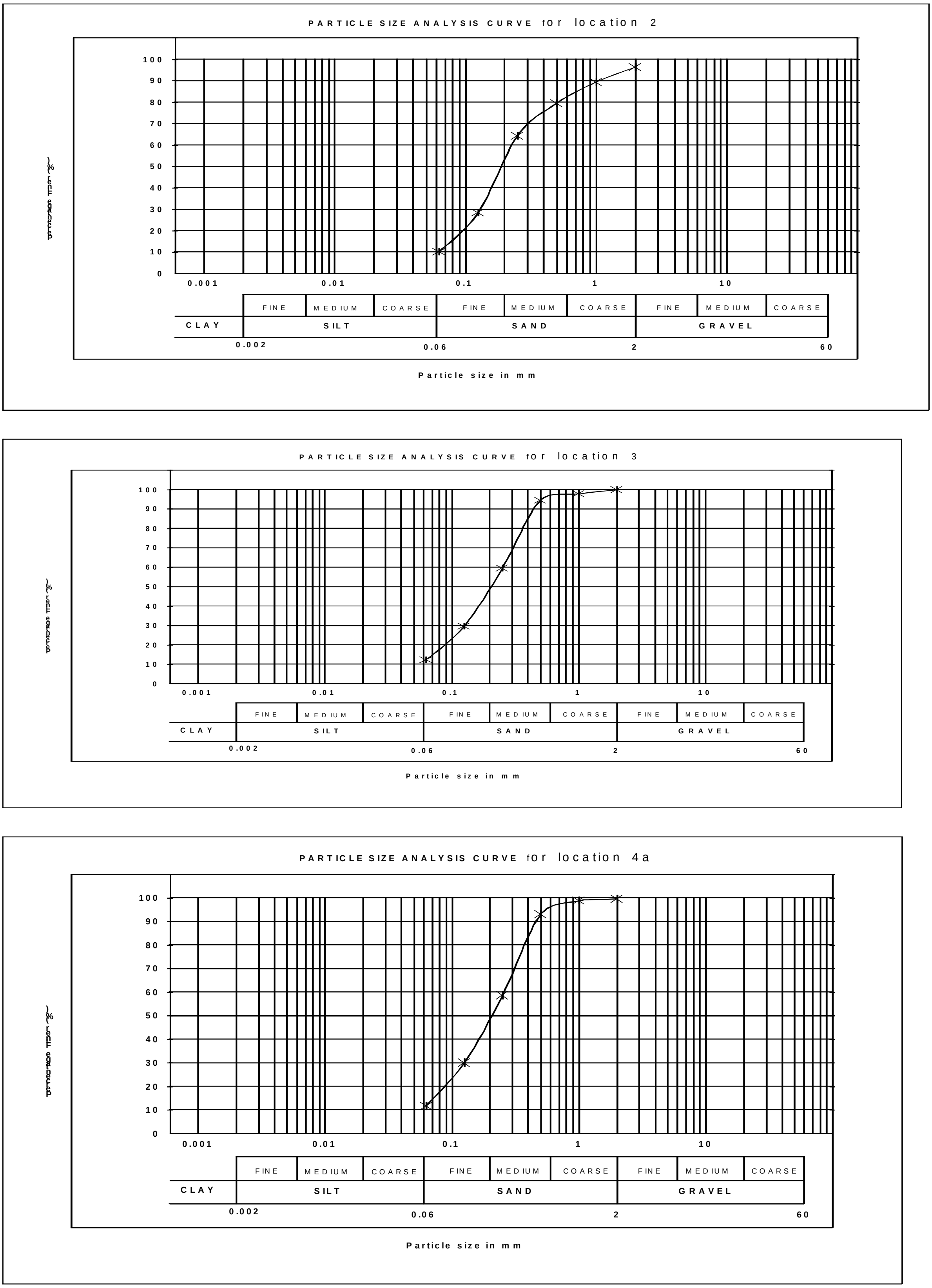


Fig. 4 : Plots of simple Skewness measure Vs sorting

Table 1: Traced phi values from the cumulative frequency curves for sandstone from study area

Sample	Loc 1	Loc 2	Loc 3	Loc 4	Loc 5	Loc 6	Loc 7	Loc 8
$\varnothing_5$	-1.50	-0.85	-0.80	-0.99	-0.80	-1.00	-2.27	-1.79
$\varnothing_{16}$	-0.10	-1.10	0.71	0.40	0.45	0.29	-1.13	-0.50
$\varnothing_{25}$	-0.30	-0.25	-0.30	0.80	0.70	0.70	0.80	0.05
$\varnothing_{50}$	0.30	0.78	0.70	1.33	1.75	1.90	0.09	0.90
$\varnothing_{75}$	1.71	1.50	1.48	1.86	1.89	2.21	0.92	1.45
$\varnothing_{84}$	2.42	2.00	1.68	2.22	2.33	2.70	1.50	1.92
$\varnothing_{95}$	3.79	2.92	2.19	3.00	3.50	2.41	2.90	2.50

$$\text{Mean} = \frac{\varnothing_{16} + \varnothing_{15} + \varnothing_{84}}{3}$$

Table 2: Graphic mean data interpretation for the study locations

Sample No	Calculated mean	Descriptive terms
Location 1	0.73	Coarse sand
Location 2	0.58	Coarse sand
Location 3	0.54	Coarse sand
Location 4	1.35	Medium sand
Location 5	1.30	Medium sand
Location 6	1.45	Medium sand
Location 7	0.13	Coarse sand
Location 8	0.73	Coarse sand

Inclusive Graphic Standard Deviation Results

$$6_1 = \frac{\varnothing_{84} - \varnothing_{16} + \varnothing_{95} - \varnothing_5}{3}$$

Where $\varnothing$ = phi

Sample No	Values of sorting	Standard value of sorting
Location 1	1.65	Poorly sorted
Location 2	1.38	Poorly sorted
Location 3	1.16	Poorly sorted
Location 4	0.74	Moderately sorted
Location 5	1.05	Poorly sorted
Location 6	1.26	Poorly sorted
Location 7	1.52	Poorly sorted
Location 8	1.22	Poorly sorted

Graphic Kurtosis Results

This indicates the peakedness of the distribution curves. Kurtosis is given by the formula;

$$Ka = \frac{\varnothing_{95} - \varnothing_5}{2.44\,(\varnothing_{75} - \varnothing_{25})}$$

where Ka = Kurtosis.

Table 3: Kurtosis data interpretation of sandstone in the study area

Sample No	Values of sorting	Standard value of sorting
Location 1	0.82	Platy kurtic
Location 2	0.86	Platy kurtic
Location 3	0.94	Meso kurtic
Location 4	1.48	Lepto kurtic
Location 5	1.41	Lepto kurtic
Location 6	1.20	Lepto kurtic
Location 7	1.24	Lepto kurtic
Location 8	1.29	Lepto kurtic

Skewness(Sk1)

$$Sk_1 = \frac{\varnothing_{16} + \varnothing_{84} - 2\varnothing_{50}}{2(\varnothing_{84} - \varnothing_{16})} + \frac{\varnothing_5 - \varnothing_{95} + 2\varnothing_{50}}{2(\varnothing_{95} - \varnothing_5)}$$

Table 4: Skewness data interpretation for sandstones in the study area.

Sample No	Values of skewness	Standard value of sorting
Location 1	1.01	Strongly finely skewed
Location 2	-0.41	Strongly coarsely skewed
Location 3	-0.65	Strongly coarsely skewed
Location 4	-0.25	Coarsed sparsely skewed
Location 5	-0.16	Coarsed sparsely skewed
Location 6	-0.02	Symmetrically skewed
Location 7	-0.04	Symmetrically skewed
Location 8	-0.06	Symmetrically skewed

Table 5: Standards for Interpretation of Pebble Morphometric Analysis

PARAMETERS	FORMULA	AUTHOR
Flatness Ratio (F.R)	Short axis/long axis (S/L)	Luttig (1962)
Elongation Ratio (E.R)	Intermediate/Long axis (I/L)	Luttig (1962)
Maximum projection sphericity index (M.P.S.I)	$(S^2/LxI)^{1/2}$	Sneed and Folk (1958)
Oblate prolate index (O.P.I)	10(L-I-0.5) / (L-S)/(S/L)	Dobkins And Folk (1970)
Roundness	Visual estimation of the pebbles	Sames (1966)

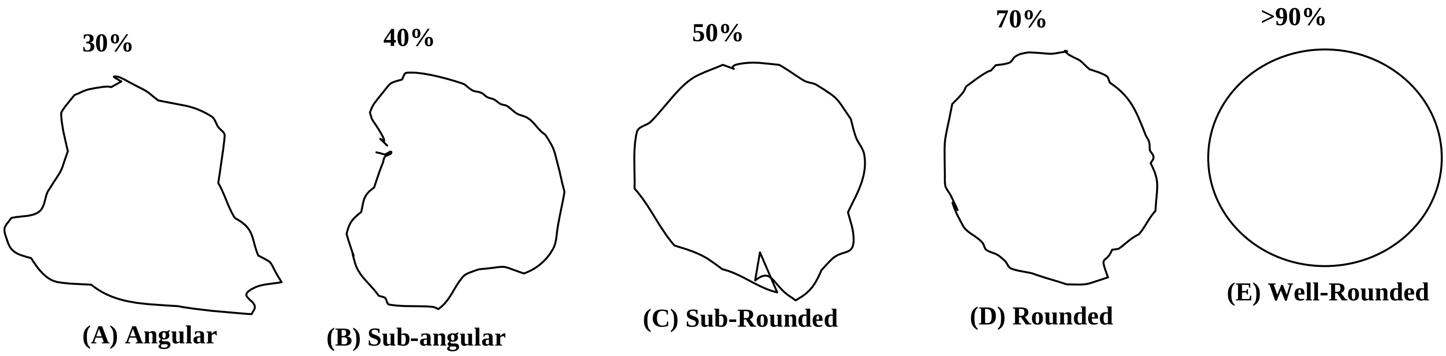


Fig 1: Roundness grades of pebbles (After Sames 1966)

Table 6:A univariant interpretation table for pebble morphometric analysis

Critical	Fluviatile	Wave
S	> 0.45%	< 0.45%
MPSI	> 0.65	< 0.65
OPI	> 1.5	< -1.5

(After Wadell 1932).

Table 7: Pebble Morphometric Data for Loc 1 (Base of M. Patti)

S/NO	L-axis (cm)	I-axis (cm)	S-axis (cm)	(F.R) S/L	(E.R) I/L	L.I L-S L-I/LS	MPSI	OPI	Roundness (%)
1	4.94	4.15	3.45	0.69	0.84	0.53	0.83	2.79	50
2	4.55	3.92	279	0.61	0.66	0.36	0.76	1.20	60
3	4.16	3.23	3.12	0.75	0.38	0.89	0.89	6.16	50
4	4.16	3.55	2.45	0.59	0.85	0.36	0.74	1.09	20
5	3.39	3.12	2.21	0.65	0.72	0.23	0.77	-4.0	20
6	3.97	3.15	2.60	0.65	0.79	0.59	0.82	3.57	70
7	3.78	3.23	2.60	0.69	0.55	0.47	0.82	0.62	60
8	3.35	2.15	2.12	0.63	0.23	0.98	0.86	8.61	40
9	3.55	2.18	2.05	0.58	0.61	0.91	0.82	10.3	30
10	3.14	2.73	1.75	0.56	0.57	0.29	0.73	-2.1	60
11	2.64	2.27	1.70	0.64	0.66	0.39	0.78	-2.1	70
12	3.05	2.31	1.82	0.59	0.76	0.60	0.78	3.27	10
13	2.81	2.40	1.60	0.57	0.35	0.34	0.73	-1.3	20
14	3.10	2.87	1.71	0.55	0.23	0.17	0.69	-3.5	50
15	2.60	2.10	1.60	0.62	0.81	0.50	0.78	0.00	25
16	2.75	2.25	1.80	0.65	0.40	0.53	0.81	0.00	30
17	3.68	2.20	1.90	0.52	0.59	0.83	0.77	10.6	40
18	2.44	2.51	2.05	0.69	0.26	0.47	0.83	1.30	20
19	3.20	2.30	1.75	0.62	0.32	0.48	0.78	0.15	10
20	3.10	1.87	1.54	0.63	0.37	0.63	0.81	1.23	30
21	2.45	2.40	2.05	0.64	0.75	0.69	0.82	-3.9	30
22	3.05	2.69	1.96	0.63	0.47	0.36	0.77	-1.1	10
23	2.45	2.40	1.69	0.69	0.86	0.15	0.79	-7.6	50
24	3.50	2.60	2.15	0.70	0.35	0.50	0.84	9.23	40
25	2.45	2.34	1.70	0.69	0.76	0.15	0.79	-7.6	30
26	3.50	2.35	1.85	0.53	0.67	0.69	0.75	13.2	40
27	1.85	1.71	1.52	0.82	0.92	0.42	0.90	-13.	50
28	2.37	2.04	1.66	0.70	0.66	0.46	0.83	-3.4	80
29	3.33	2.75	1.86	0.56	0.53	0.39	0.73	0.97	60
30	2.95	2.05	1.73	0.59	0.69	0.74	0.79	5.5	20
AVG	**3.22**	**2.70**	**2.10**	**0.60**	**0.48**	**0.50**	**0.70**	**0.90**	**38.8**

Table 8: Pebble Morphometric Data for Location 2 (Top of M. Patti)

S/NO	L-axis (cm)	I-axis (cm)	S-axis (cm)	(F.R) S/L	(E.R) I/L	L-I/LS	MPSI	OPI	Roundness (%)
1	3.25	3.02	2.67	0.82	0.43	0.40	0.94	-5.67	80
2	5.99	3.39	3.04	0.50	0.60	0.89	0.80	14.29	70
3	5.66	4.10	3.18	0.56	0.72	0.63	0.83	7.61	20
4	4.88	4.17	2.28	0.46	0.35	0.27	0.78	1.73	30
5	5.95	3.00	2.21	0.37	0.50	0.79	0.72	1.76	60
6	3.85	3.06	2.15	0.56	0.79	0.46	0.83	3.05	30

7	3.88	2.95	2.10	0.54	0.75	0.52	0.82	4.46	10
8	4.25	4.09	3.06	0.72	0.26	0.13	0.90	-3.97	80
9	4.55	3.05	2.37	0.52	0.67	0.69	0.81	0.88	50
10	4.05	3.85	2.55	0.63	0.75	0.13	0.86	-3.18	40
11	4.17	2.90	2.15	0.52	0.20	0.63	0.77	7.39	60
12	5.20	3.25	2.63	0.51	0.63	0.76	0.80	11.16	30
13	3.75	3.15	2.80	0.75	0.34	0.63	0.91	1.41	20
14	4.33	3.45	2.50	0.58	0.30	0.48	0.83	3.60	30
15	3.90	3.00	2.32	0.59	0.29	0.52	0.84	3.51	25
16	3.85	3.28	2.35	0.61	0.85	0.38	0.85	0.76	40
17	3.80	3.32	2.95	0.78	0.87	0.56	0.92	-0.30	80
18	3.92	3.35	2.65	0.68	0.60	0.37	0.88	0.82	70
19	3.79	2.75	2.35	0.62	0.33	0.72	0.85	5.60	40
20	3.83	3.05	2.30	0.60	0.30	0.51	0.85	3.05	20
21	3.32	2.15	1.75	0.53	0.65	0.75	0.76	8.10	50
22	3.24	2.50	2.00	0.64	0.77	0.63	0.81	3.21	60
23	3.05	2.35	2.25	0.74	0.27	0.88	0.89	3.39	20
24	2.30	1.93	1.80	0.78	0.84	0.74	0.90	-3.32	90
25	3.30	2.45	1.72	0.52	0.74	0.54	0.87	-3.58	25
26	2.15	2.07	1.66	0.77	0.26	0.16	0.85	-11.1	60
27	3.80	2.97	2.10	0.75	0.70	0.49	0.73	3.51	40
28	3.03	2.70	1.83	0.60	0.69	0.28	0.74	-6.07	50
29	2.67	2.45	1.82	0.68	0.22	0.26	0.80	-4.83	80
30	3.12	2.71	1.65	0.53	0.87	0.28	0.69	-1.16	60
AVG	**3.80**	**4.30**	**2.40**	**0.60**	**0.55**	**0.50**	**0.70**	**1.50**	**47**

Table 9: Pebble Morphometric Data for Location 3 (0.67km North A.D.P Felele)

S/NO	L-axis (cm)	I-axis (cm)	S-axis (cm)	S/L (cm)	I/L (cm)	L-I/LS	MPSI	OPI	Roundness (%)
1	3.73	3.60	2.55	0.68	0.97	0.12	0.94	-4.59	60
2	3.68	2.77	2.66	0.72	0.75	0.89	0.89	5.56	15
3	3.32	3.13	2.12	0.64	0.24	0.16	0.76	-4.05	40
4	3.77	3.02	2.17	0.58	0.80	0.47	0.75	2.71	20
5	4.20	3.22	2.50	0.59	0.37	0.58	0.78	4.74	80
6	4.37	3.69	2.25	0.51	0.84	0.32	0.68	1.65	60
7	3.90	3.60	2.29	0.72	0.72	0.27	0.82	-2.52	80
8	3.38	3.12	2.12	0.63	0.48	0.21	0.75	1.00	30
9	3.80	3.04	2.20	0.58	0.78	0.48	0.75	-1.73	20
10	3.55	2.35	1.00	0.28	0.27	0.47	0.50	9.49	30
11	2.83	2.80	2.23	0.79	0.79	0.05	0.86	-9.94	40
12	3.23	2.70	2.23	0.69	0.34	0.53	0.73	-14.0	60
13	3.35	2.58	1.80	0.54	0.27	0.49	0.72	3.24	30
14	2.94	2.50	2.10	0.71	0.85	0.52	0.50	-2.00	70
15	2.25	2.11	1.59	0.78	0.42	0.21	0.81	-7.72	30
16	3.20	2.68	2.20	0.69	0.84	0.52	0.56	1.29	20
17	3.90	2.30	2.05	0.53	0.59	0.86	0.78	11.30	10
18	2.69	2.67	2.05	0.78	0.73	0.03	0.84	-9.84	50
19	2.57	2.20	2.12	0.82	0.26	0.82	0.36	-3.50	30
20	3.54	2.95	2.08	0.59	0.33	0.40	0.75	1.05	10
AVG	**3.35**	**2.94**	**2.10**	**0.60**	**0.58**	**0.40**	**0.80**	**0.90**	**39.25**

Table 10: Pebble Morphometric Data for Location 4 (Felele Lokoja)

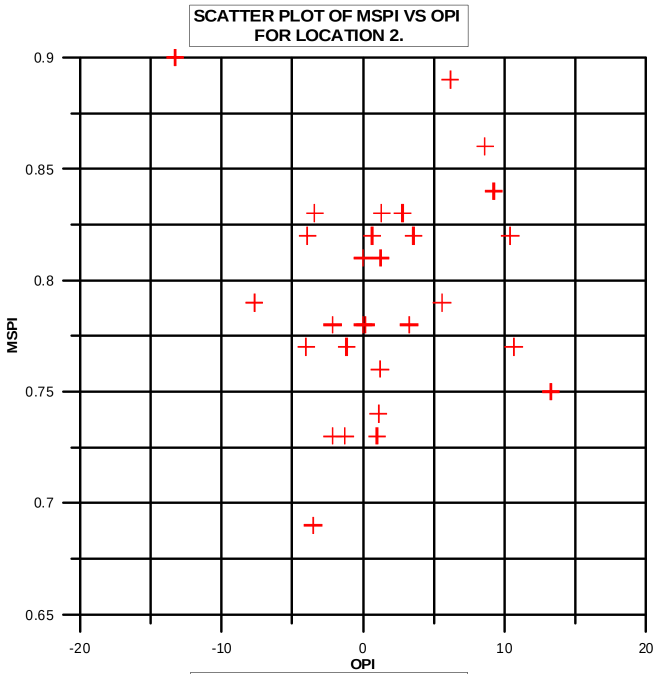
S/NO	L-axis (cm)	I-axis (cm)	S-axis (cm)	S/L (cm)	I/L (cm)	L-I/LS	MPSI	OPI	Roundness (%)
1	4.00	2.94	2.36	0.59	0.74	0.65	0.78	5.79	50
2	3.48	2.30	2.19	0.63	0.36	0.91	0.84	8.38	20
3	3.31	2.29	2.10	0.63	0.49	0.84	0.84	6.78	30
4	2.62	2.33	1.70	0.63	0.68	0.32	0.78	-3.5	60
5	4.22	2.77	2.40	0.57	0.46	0.80	0.79	9.18	30
6	2.87	2.63	1.84	0.64	0.72	0.23	0.77	-7.5	30
7	3.38	2.87	2.27	0.67	0.25	0.46	0.51	0.14	20
8	4.10	2.87	2.50	0.61	0.70	0.77	0.81	7.48	40
9	3.73	2.93	2.42	0.65	0.78	0.61	0.82	3.53	30
10	3.30	2.43	2.03	0.62	0.24	0.69	0.80	4.74	70
11	3.25	3.20	2.32	0.71	0.38	0.10	0.80	-6.7	80
12	2.27	3.02	1.85	0.57	0.72	0.18	0.70	-3.1	30
13	2.85	2.05	1.05	0.37	0.22	0.44	0.52	4.52	50
14	2.78	2.60	1.80	0.65	0.34	0.18	0.77	-5.0	20
15	3.08	2.70	1.94	0.64	0.89	0.32	0.77	-2.3	80
16	2.85	2.46	2.31	0.81	0.46	0.72	0.91	-2.5	20
17	2.85	2.36	2.05	0.72	0.82	0.63	0.86	0.00	50
18	3.43	3.05	1.78	0.53	0.71	0.19	0.48	-2.5	40
19	3.12	2.82	1.67	0.54	0.30	0.21	0.68	-2.5	30
20	2.20	2.00	1.80	0.82	0.71	0.50	0.90	-1.9	60
AVG	**3.20**	**2.60**	**2.06**	**0.80**	**0.54**	**0.50**	**0.70**	**0.23**	**42**

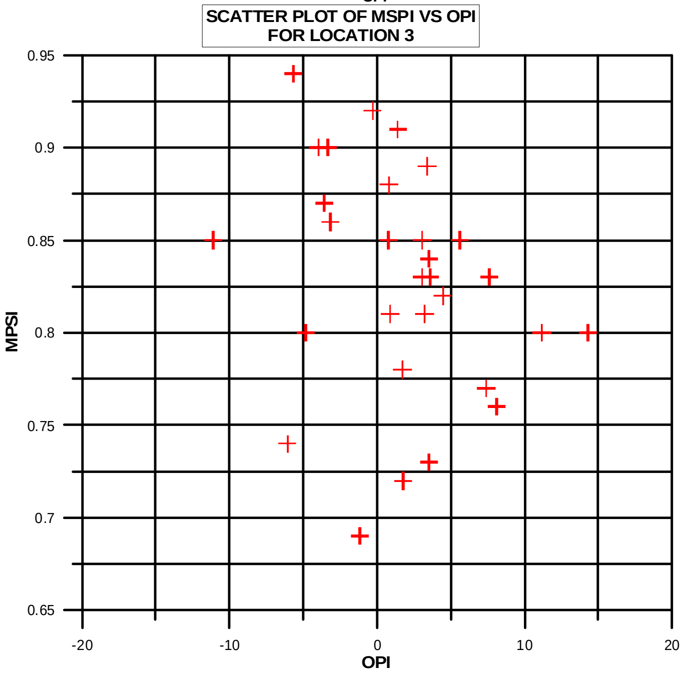
TOTAL AVERAGE OF ROUNDNESS

$$= \frac{38.8+47.0+39.25+42.0}{4} = \frac{167.05}{4} = 41.76 = 41.8\%$$

Table 11: Summary of Pebble Morphometric Parameters

Morphometric Parameters	Total mean pebble set
Flatness ratio (F.R)	0.650
Elongation ratio (E.R)	0.540
Maximum Projection Sphericity Index (M.P.S.I)	0.730
Oblate prolate index (O.P.I)	0.830
Roundness (%)	41.8
Pebble size (magnitude)	3.39


SCATTER PLOT OF MSPI VS OPI
FOR LOCATION 2.
MSPI
OPI
0.9
0.85
0.8
0.75
0.7
0.65
-20
-10
0
10
20


SCATTER PLOT OF MSPI VS OPI
FOR LOCATION 3
MPSI
OPI
0.95
0.9
0.85
0.8
0.75
0.7
0.65
-20
-10
0
10
20

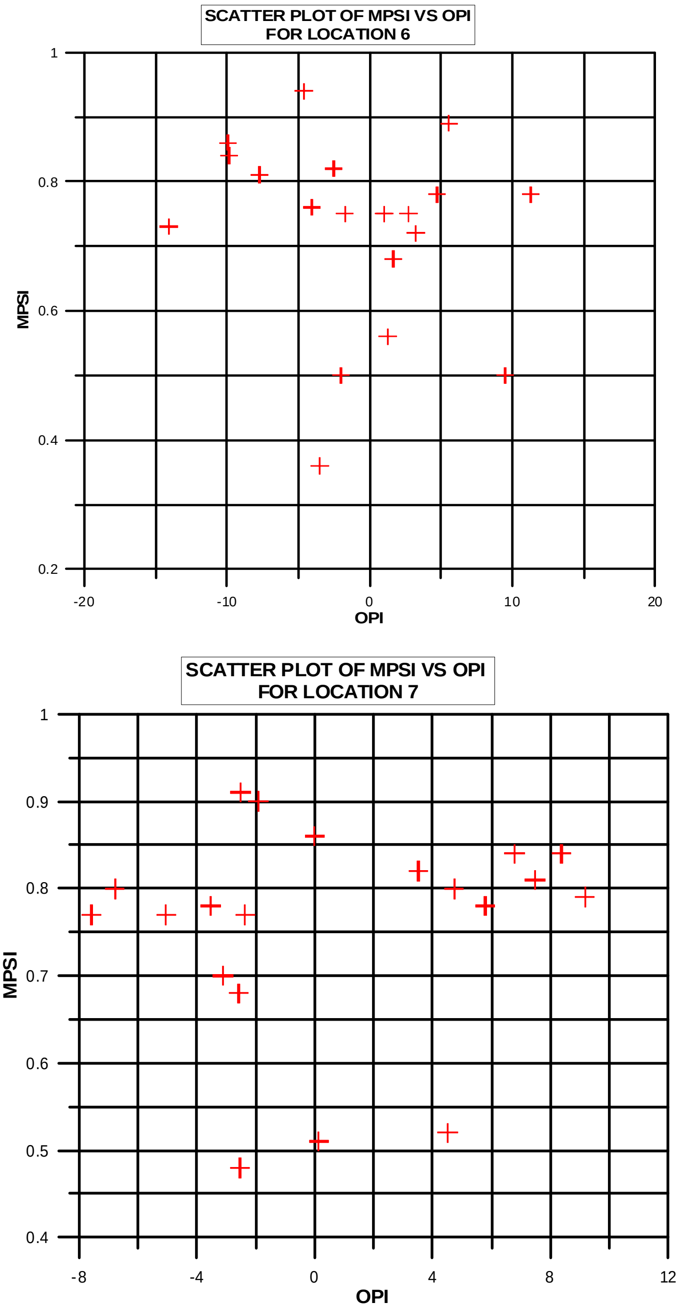
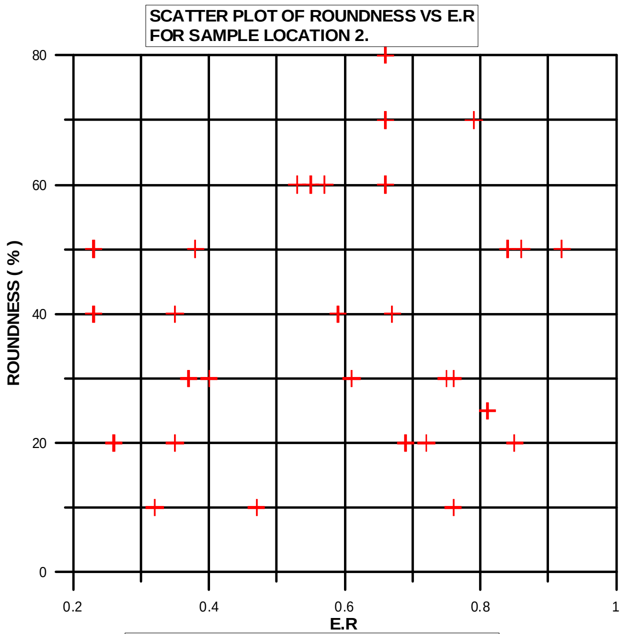
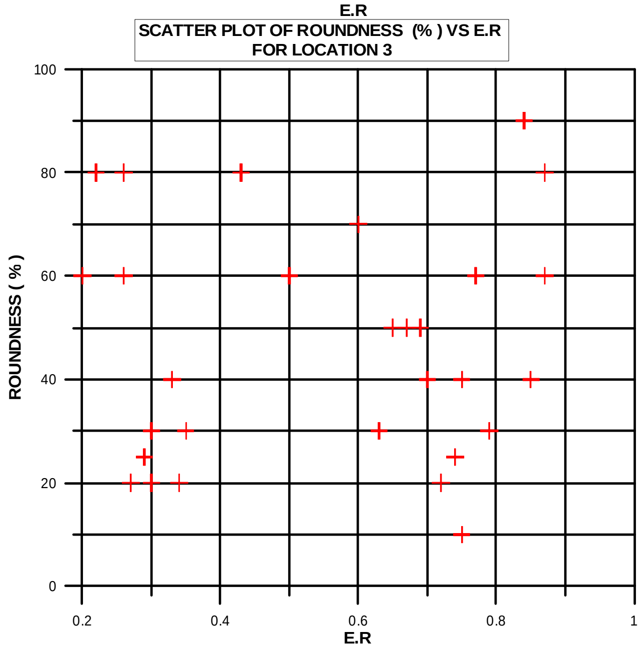
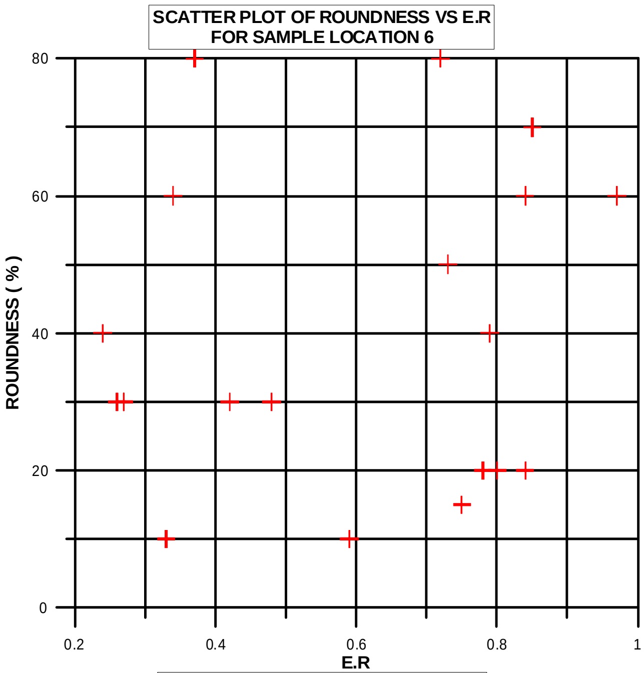


Fig. 5a : Scatter Plots MPSI Vs OPI


SCATTER PLOT OF ROUNDNESS VS E.R
FOR SAMPLE LOCATION 2.
ROUNDNESS (%)
E.R
0
20
40
60
80
0.2
0.4
0.6
0.8
1


SCATTER PLOT OF ROUNDNESS (%) VS E.R
FOR LOCATION 3
ROUNDNESS (%)
E.R
0
20
40
60
80
100
0.2
0.4
0.6
0.8
1



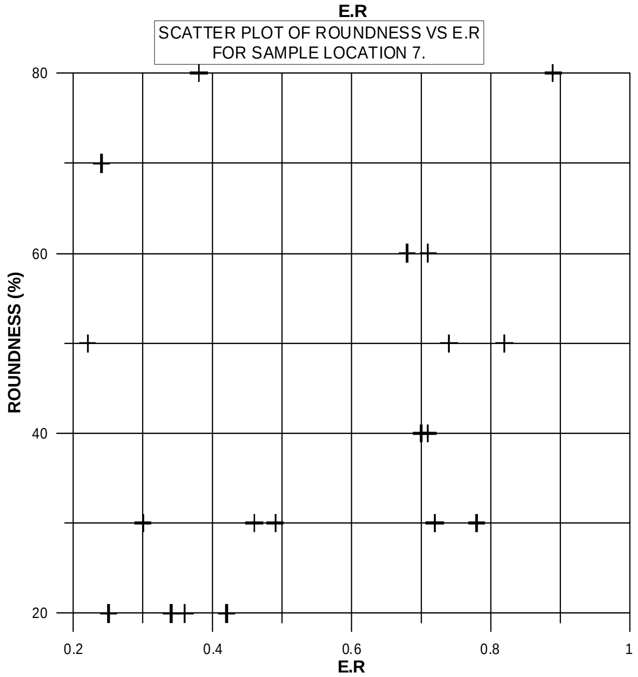


Fig. 5b : Scatter Plots of Roundness

Percentage (%) Composition of the heavy mineral suites for the Lokoja sandstone

Mineral	Loc 2	Loc 6	Loc 8	Optical properties
Zircon	7	17	25	Colourless with sub – rounded grains in thin section and exhibit high birefringence due to the high polarization colour
Tourmaline	14	26	18	Black usually, but green, reddish colour on rotation with good prismatic cleavage.
Rutile	5	4	9	Small crystals observed and yellow – reddish in colour.
Staurolite	5	21	13	Almost yellow and shows pleochroism on rotation with yellow polarization colour.
Andalusite	-	2	4	Grey to purplish and prinkish red with elongated crystals.
Kyanite	4	3	5	Colourless and pale blue on rotation.
Sillimanite	8	2.8	-	Colourless and small crystals observed.
Sphene	2	-	0.5	Reddish to brownish in thin section with small crystals.
Topaz	-	2	1	Commonly pale yellow to orange colour with pyramidal faces.
Opaque	50	18	21	Commonly occurs as dark green composed of iron oxide minerals mainly haematite.
Garnet	4	3	2	Occur as colourless to pinkish colour with almost circular polygonal crystal.
Average composition	98%	97.8%	97.5%	

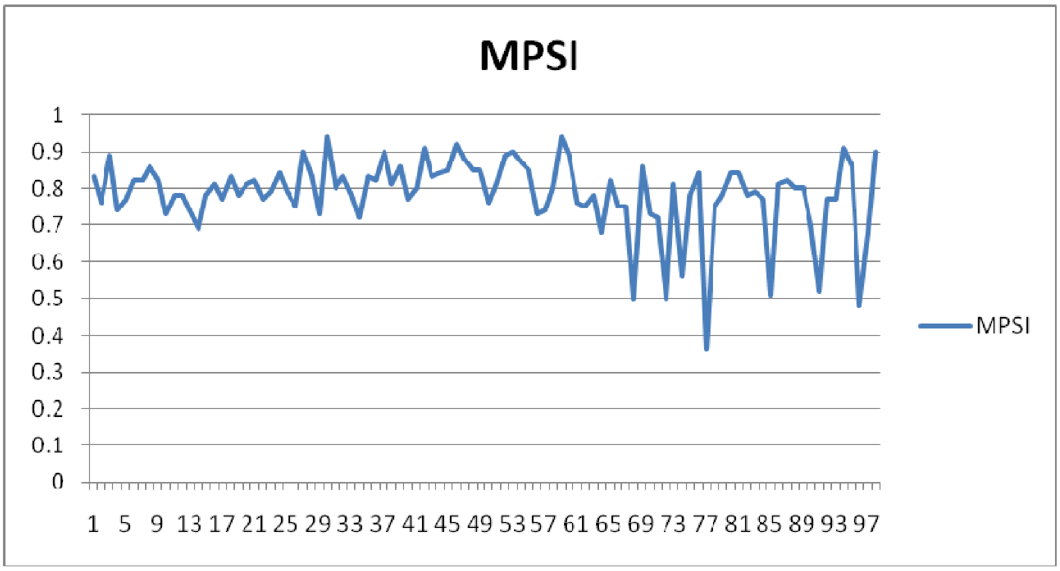
DISCUSSION OF RESULTS

The result of the grain size analyses show that the Lokoja sandstones are generally poorly sorted, medium to coarse grain in texture indicating both less winnowing and abrasion. Consequently, the grains probably retained original configuration and texture. This is an indication of rapid deposition and short distance of transportation reflecting a fluvial setting (Friedman 1979). The result of simple skewness measure and sorting measure (Table 8) reflects a positively skewed and poorly sorted grains indicatives river sands (Friedman, 1979). Kurtosis plots indicate a range from platykurtic to leptokurtic.

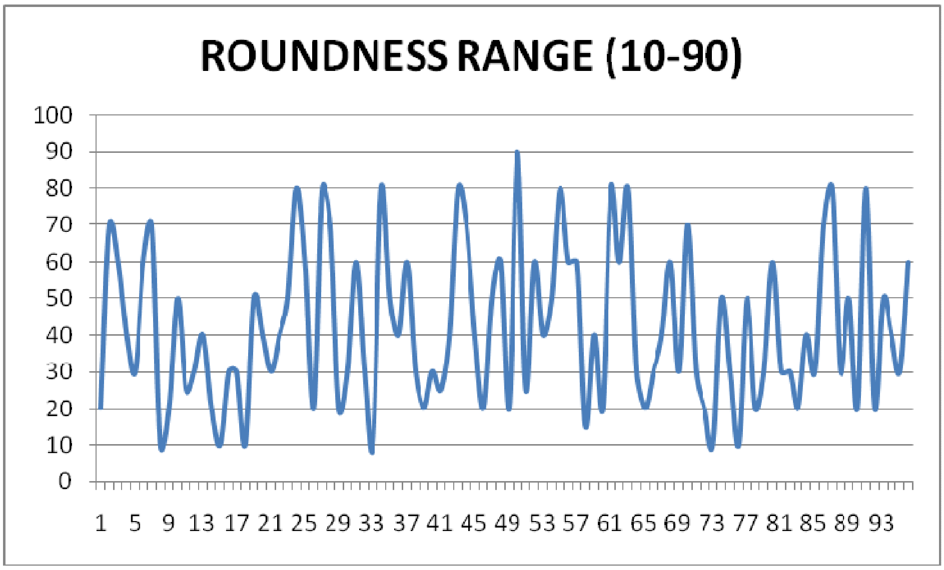
The magnitude of the long axis of pebbles determines the size (Nwajide and Hoque, 1985). The mean size of the pebbles is 3.39cm. This is an indication of fluvial channels.

The measure of equidimensionality (sphericity) of the pebbles was determined using the maximum projection sphericity index (MPSI). The MPSI value 0.66 separates the Beach from River Pebbles. The mean MPSI value of 0.730 which is compact bladed indicates fluvial origin. The total mean flatness ratio of 0.650 indicates marine environment for the pebbles (Lutig 1962). The mean elongation ratio obtained is 0.540 which indicates current type flowing. This suggests that, the pebbles range from equate to prelate which indicates fluvial channels to dissocial pebbles, an indication of littoral channels. The scatter plots of MPSI Vs OPI (Fig.5) suggests that the pebbles are concentrated more in river area than in the beach area, which indicates a fluvial condition for the pebbles.

Roundness is an indication of the extent of abrasion, determined by the distance of transportation of pebbles rather than the depositional environment. The result obtained shows that, the pebbles have roundness values ranging from 10 – 90% (angular to well rounded). The total average roundness of 41.8% (0.418), shows that the pebbles are dominantly sub-rounded (table11) indicating short distance of travel. The pebble might have been transported from the weathering of neighboring basement rocks of the Western and Northern Nigeria.



Mean plot of MPSI



Roundness Range and concentration plot

The result of the heavy mineral analysis reveal non – opaque mineral suite including Zircon, Tourmaline, Rutile, Staurolite, Garnet, Kyanite and Sphene while the Opaque minerals constitute a range of 18 – 48% mainly of Haematite, Ilmenite, Magnetite and Pyrite. These heavy mineral suites occurs as detrital grains in the samples which indicates that, the sediments were derived from the basement complex of igneous and metamorphic rocks; probably the Southwestern Precambrian domain. Zircons, Tourmaline, Sphene, Topaz, and Opaques are typical of igneous rock source (e.g granite, pegmatite, syenite e.t.c), while staurolite, sillimanite, rutile, andalusite, kyanite, garnet are derived from metamorphic rocks (e.g. marble, schist, gneisses e.t.c). The Zircon – Tourmaline – Rutile (ZTR) index in the samples ranges from 10 – 26% which indicates immature sandstone (Hoque and Ezepue, 1977).

The wide spread heavy mineral species recovered from the samples indicates that the sediments are probably of younger age (Petti John, 1975) because of less intrastratal dissolution. The percentage of the haematite is an indication that the sediments were deposited in an oxidizing environment under fluvial condition.

CONCLUSION

The study area, part of Campanian – Maastritchian Formation revealed the occurrence of basal conglomerates, massive to pebbly sandstones, sandysilt and claystone units with overlying laterite and ironstone capping which shows a fining upward sequence indicating a fluvial environment for the Lokoja sandstones.

Results of grain size analysis show that, the sandstones range from medium to coarse grain, poorly sorted suggesting less winnowing, abrasion, hence the grains retain the original configuration and texture. This suggests a fluvial setting for the Lokoja sandstones. The pebble morphometric analyses indicate a fluvial depositional environment for the Lokoja sandstone. The scatter plots of Roundness versus Elongation ratio delineate angular to sub-rounded pebbles. The low roundness value [0.41] is an indication of fluvial environment and short transportation history. The heavy mineral suites indicate that the sediments were derived from the basement rocks probably from the southwestern and the northcentral domains.

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