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Sedimentology and Depositional Environment of part of Lokoja Formation Exposed at Felele Junction, Southern Bida Basin

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Abstract

The exposed Campanian sedimentary sequence at Felele junction around Lokoja has been mapped, logged and sampled. The total thickness of the section is approximately 21.48m. The sediments consist of conglomeratic sandstones, coarse sandstones and mudstones. Grain size analysis performed on nineteen sandstone samples revealed the average values of mean, sorting, skewness and kurtosis as 0.6, 1.03, 0.53 and 0.76 respectively. These results show that the sandstones are coarse grained, poorly sorted, strongly fine skewed and platykurtic. This characteristic is typical of fluvial depositional environment. The plots of skewness against sorting, sorting versus kurtosis and mean against sorting suggest a fluvial depositional environment. Petrographic analysis of selected sandstones reveals the presence of quartz, feldspars (plagioclase and microcline) and mica (biotite and muscovite). Quartz (especially monocrystalline) dominates followed by feldspar with minor muscovite and biotite. Heavy mineral study revealed the presence of non-opaque mineral suites suggesting that the sediments are derived from the basement complex of igneous and metamorphic rocks. The heavy minerals observed include staurolite, rutile, kyanite, zircon and sphene. The samples are dominated by stauronite which signifies low grade metamorphism in the area. Integration of sedimentological and petrographical characteristics in this study suggest that the sandstone samples are derived from mixed origin and deposited in fluviatile environment under high energy setting not too far from the source. Hence it is a proximal deposit.

Keyword: Bida, Lokoja, Campanian, Environment, Feldspar, Quartz

1. Introduction

The Bida basin, located at central Nigeria, is one of the hinterland sedimentary basins in Nigeria, having a sedimentary fill of about 4km (Ojo, 1984; Udensi and Osasuwa, 2004). It is

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a northwest-southeast trending intracratonic structural depression adjacent and contiguous with Sokoto and Anambra basins in the northwest and southeast respectively. The Bida basin is subdivided into the northern and southern sub-basins to accommodate the fast and wide facies changes across its long and large areal extent (Braide, 1992; Jones, 1955).

The Bida basin is a NW–SE trending rift related sedimentary basin extending from Kontagora (Niger State), Nigeria to areas around Lokoja (Kogi State) in the south. It is bounded in the northeast and southwest by the basement complex while it merges with Anambra and Sokoto basins in a sedimentary fill comprising post orogenic molasse facies and a few thin unfolded marine sediments Adeleye (1974). A lot of published works have been done with regards to the structural and tectonic origin and even stratigraphic setting of Bida basin. In the recent years geoscience research in the Bida basin (especially the Southern Bida basin) has tends towards the source rock potential and reservoir rock characteristics. The present work has focused on the evaluation of grain size parameters for modal analysis and textural characteristics, petrographic composition of the sandstones, heavy mineral components for provenance study and depositional environment. This aspect has not been thoroughly study before. There are lots of controversy which this study has been able to clarify. The location of the study area is Felele Junction around Lokoja in the Southern Bida Basin. It is about 1km north of the NATACO junction (Fig 1). The study area falls within latitudes 7^0 48`N - $7^0$ 57`N and longitude 6^0 42`E - $6^0$ 45`E on Lokoja sheet 247 NW. The area consists predominantly of late Cretaceous clastic sediments of the Lokoja Formation.

The tectonic origin of the Bida basin has been discussed by several authors. Kennedy (1965) described a rift bounded tensional structure produced by faulting associated with the Benue Trough system and break-up of the Gondwana. Landsat imageries analysis by Kogbe *et al*. (1981) indicates that the southern Bida Basin is controlled by NW-SE trending faults which supports a rift model. The existence of a deep seated central positive anomaly flanked by negative anomalies typical of rift structure was confirmed by the geophysical study of Ojo and Ajakaiye (1989). Whiteman (1982) proposed that the Bida Basin is post-Santonian shallow cratonic sag whilst Braide (1992) suggests the idea of pull-apart origin for the basin. Several authors have worked on the stratigraphic setting of the southern Bida basin including Adeleye and Dessauvagie (1972), Braide (1992), Ladipo (1994), Obaje *et al.* (2011); Ojo and Akande (2003), Ojo and Akande (2006); Olaniyan and Olobaniyi (1996), Olugbemiro and Nwajide (1997) among others. These authors have identified and described in details (from the oldest to youngest) principally three major formations in the Southern Bida Basin including Lokoja Formation, Patti Formation and Agbaja Formation (Fig. 2a and Fig. 2b).

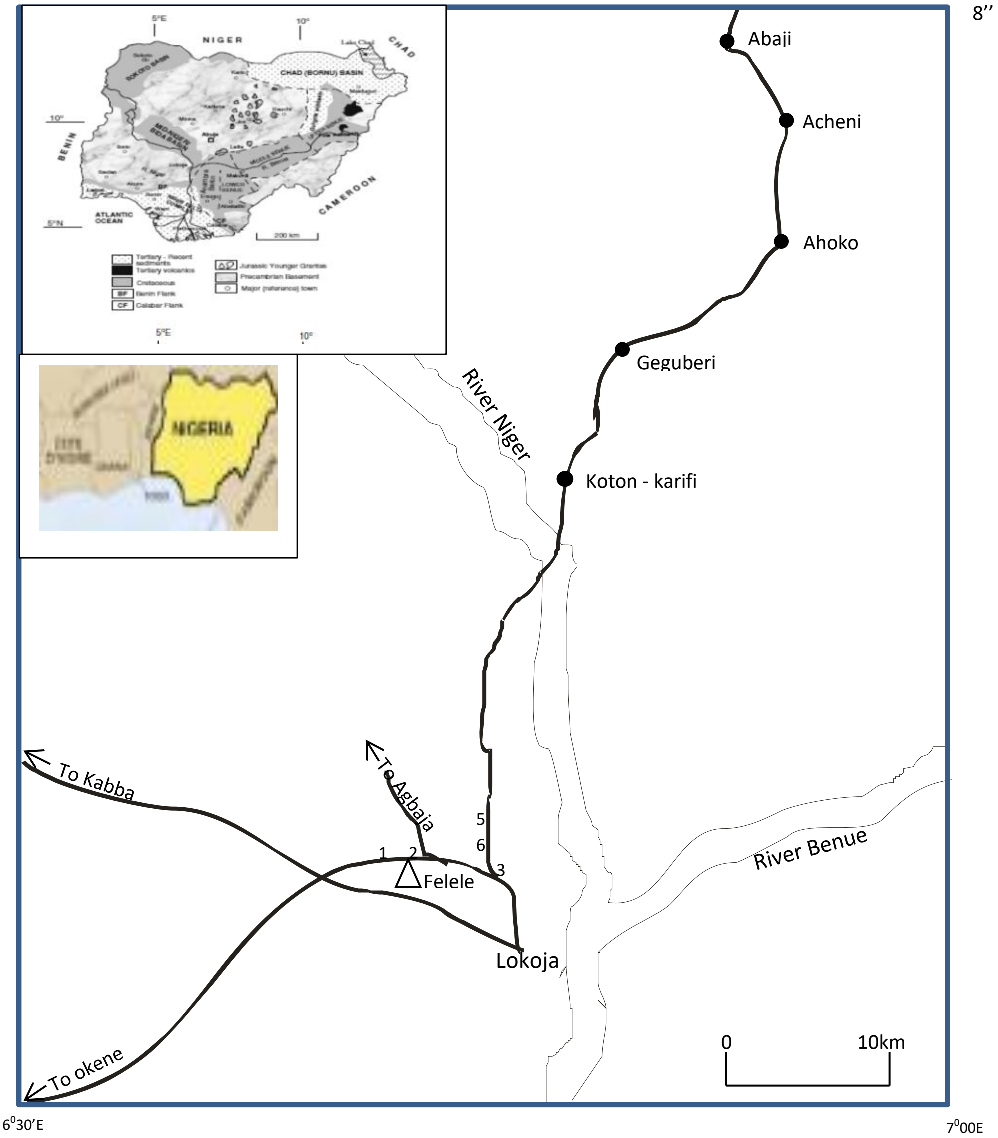


Figure 1: Location of the study area on a simplified geological map of Nigeria (modified from Ojo and Akande, 2003). (△ Location of the study area).

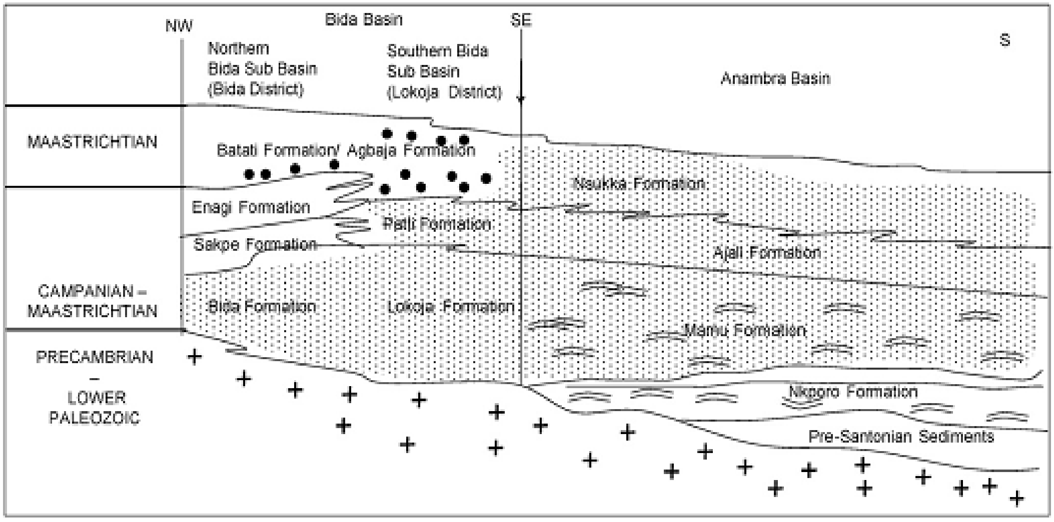


Figure 2a: Regional stratigraphic successions in the Bida Basin and restored NW-SE-S stratigraphic relationships from the Bida Basin to the Anambra Basin (Modified after Akande *et al*. 2005)

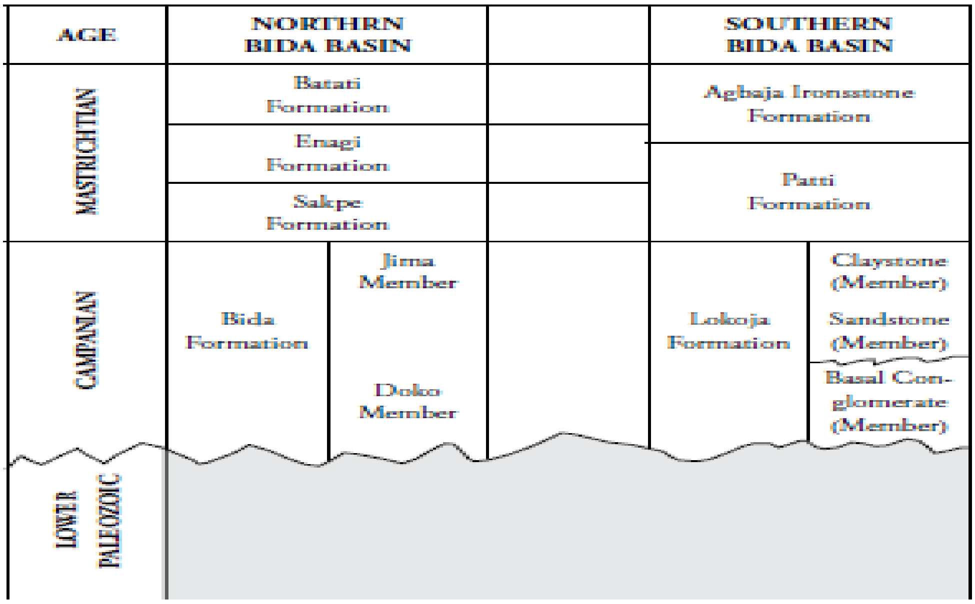


Figure 2b: Stratigraphic succession of mid-Niger Basin (adapted from Akande *et al.*, 2005)

2. Materials and Methods

Field work exercise was carried out in the month of November 2013 for about six days. During this period, bed by bed lithologic logging and measurements, section description and sample collections were carried out. Sedimentological characteristics including grain size, textural characteristics and grain orientations plus structural features were studied. Fresh representative samples were collected for laboratory analysis. The total thickness of the Lokoja Formation exposed at Felele Junction is 21.48m. The following materials and tools were used on the field: topographical map, compass clinometers, hammer and chisel, the global positioning system (GPS), hand lens, sample bags, measuring tape, masking tape, digital camera, field note, markers and pencils. All field observations were noted and recorded in the field notes.

Grain size analysis was carried out in the sedimentology laboratory of the Department of Geology and Mineral Sciences, University of Ilorin. Mechanical dry sieving method was employed in this study. Grain size is the most fundamental property of sediment particles, affecting their transportation and deposition. Grain size analysis therefore provides important clues to the sediment provenance, transport history and depositional conditions (Bui *et al*., 1990; Folk and Ward, 1957; Friedman, 1979). 100 grams each of the dry sandstone samples were weighed and gently transferred to the stacked sieves. The sieve shaker machine was powered electrically and allowed to agitate the samples for about 10 minutes. By this, the coarsest grains were retained on the topmost sieve while the finest particles were retained in the pan. Thin sections of the sandstone samples were prepared and studied for petrographic characteristics. Heavy mineral analysis was also done. The heavy mineral analysis was carried out in a well-ventilated place at the Department of Geology and Mineral Sciences, University of Ilorin using bromoform reagent. All the photomicrographs were done in the Department of Geology and Mineral Sciences, University of Ilorin.

3. Result and Discussion

3.1 Description of Exposed Lithologic Section

The total thickness of the exposed Lokoja Formation at Felele Junction is approximately 21.48m (Fig.3). It is made up of a base of medium to coarse grained sandstone that is 0.68m thick that lies unconformably on the basement complex with clasts of angular quartz and feldspar grains. This bed is overlain by ferruginised mudstone that is 0.6m thick and followed by matrix supported pebbly sandstone that is 1.22m thick (Fig. 3). Overlain this is partly ferruginised conglomeratic sandstone that is 1.9m thick, feldsparthic with clay matrix supported which is in turn overlain by 4.42m thick pebbly sandstone, whitish in colour with angular to sub-angular shape. This bed is overlain by 1.1m thick ferruginised pebbly sandstone, which is also overlain by a medium to coarse grained sandstone with occurrence of pebbles alignment that is 0.76m thick with milky colour (Fig. 4a and 4b). The bed overlying this is 4.5m thick poorly laminated conglomeratic sandstone with reddish-brown colouration which is in turn overlain by 1.30m thick medium to coarse grained sandstone that is brownish in colour. Reddish-brown conglomeratic sandstone with clay matrix support that is 5m thick (Fig. 5) forms the top of the section. Reddish-brown lateritic overburden caps the section.

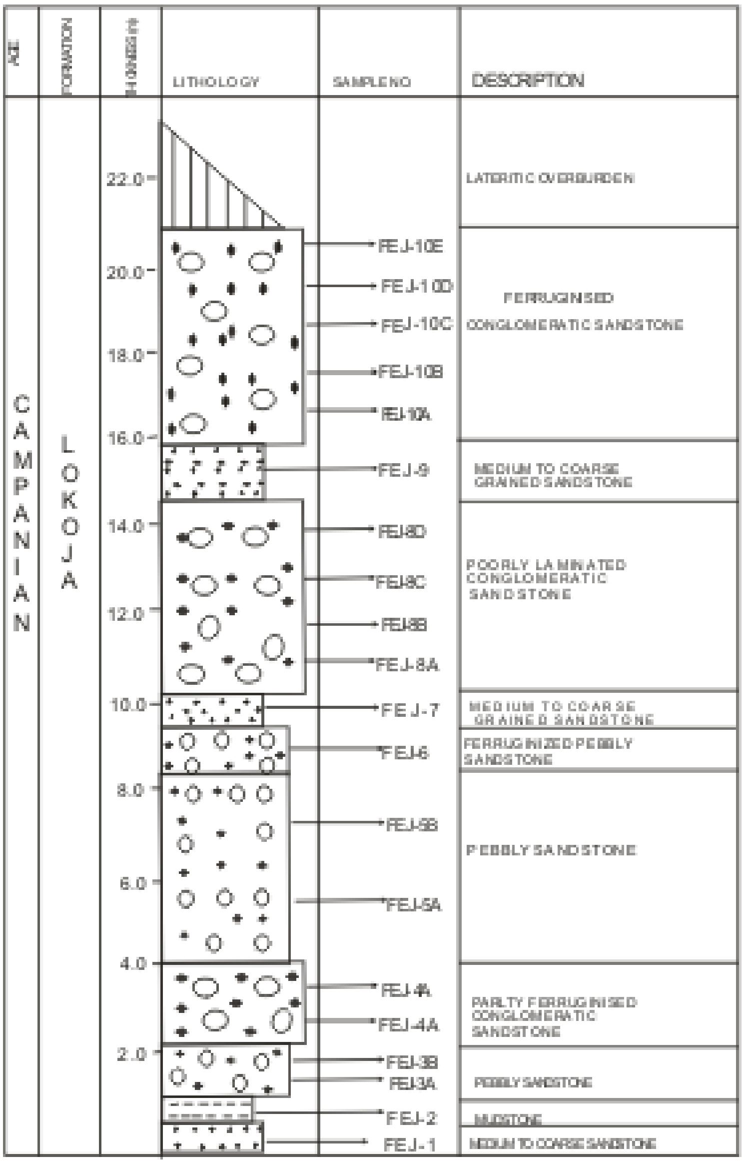


Figure 3: Lithostratigraphic section of Lokoja Formation exposed at Felele Junction

Figure 4a: Field photographs showing alignment of pebbles within the medium to coarse grained sandstone showing direction of paleocurrent in bed FEJ-7

Figure 4b: Field photographs showing alignment of pebbles within the medium to coarse grained sandstone showing direction of paleocurrent in bed FEJ-7

Figure 5: Field photograph showing matrix supported conglomeratic sandstone in bed FEJ-10

3.2 Granulometrical Analysis

The results of the grain size analysis are presented in Table 1 (Appendix I). The cumulative frequency curves for the samples identified traction, saltation and suspension as the possible mechanism of sediment transport and deposition while the grain size frequency histograms show both unimodal and bimodal asymmetric grain size distribution pattern with shifting mode. These suggest some variations in the energy of the current that deposited the sandstones. Folk and Ward (1957) formula was used to interpret the grain size parameters as discussed below.

Table 1: Summary of grain size analysis results and interpretation

Sample no	Mean	sorting	Kurtosis	Skewness	Interpretation and Results			
					Mean	**Sorting**	**Kurtosis**	**Skewness**
FEJ-1	0.7	1.50	0.50	0.1	Coarse Sand	Poorly sorted	Very platykurtic	Fine skewed
FEJ-3A	1.1	1.3	1.1	-0.1	Medium sand	Poorly sorted	Mesokurtic	Near symmetrical
FEJ-3B	0.9	1.3	1.0	0.11	Medium sand	Poorly sorted	Mesokurtic	Fine skewed
FEJ-4A	1.0	1.1	1.50	-0.07	Coarse sand	Poorly sorted	Leptokurtic	Coarse symmetrical
FEJ-4B	0.5	1.8	2.2	0.36	Coarse sand	Poorly sorted	Very leptokurtic	Strongly fine skewed
FEJ-5A	1.4	1.0	1.60	0.08	Medium sand	Poorly sorted	Very leptokurtic	Near symmetrical
FEJ-5B	1.1	1.7	0.50	0.20	Medium sand	Poorly sorted	Very platykurtic	Fine skewed
FEJ-6	1.1	1.82	0.22	-0.11	Medium sand	Poorly sorted	Very platykurtic	Coarse skewed
FEJ-7	1.60	1.20	1.30	0.02	Medium sand	Poorly sorted	Leptokurtic	Near symmetrical
FEJ-8A	-0.40	0.90	0.50	0.50	Very coarse sand	Moderately well sorted	Very platykurtic	Strongly fine skewed
FEJ-8B	0.40	1.10	1.0	-0.26	Coarse sand	Poorly sorted	Mesokurtic	Coarse skewed
FEJ-8C	0.70	1.0	1.20	-0.20	Coarse sand	Poorly sorted	Leptokurtic	Coarse skewed
FEJ-8D	1.0	1.10	1.90	-0.10	Coarse sand	Poorly sorted	Very leptokurtic	Coarse skewed
FEJ-9	0.80	1.30	1.30	-0.20	Coarse sand	Poorly sorted	Leptokurtic	Coarse skewed
FEJ-10A	-0.07	0.31	-0.98	3.0	Coarse sand	Very well sorted	Very platykurtic	Strongly fine skewed
FEJ-10B	-0.13	0.30	0.20	3.70	Coarse sand	Very well sorted	Very platykurtic	Strongly fine skewed
FEJ-10C	-0.20	-0.08	-0.19	1.0	Very coarse sand	Very well sorted	Mesokurtic	Strongly fine skewed
FEJ-10D	0.070	0.80	0.50	0.90	Very coarse sand	Moderately sorted	Very platykurtic	Strongly fine skewed
FEJ-10E	0	0.14	-0.74	0.50	Very coarse sand	Very well sorted	Very platykurtic	Strongly fine skewed

Graphic mean

Graphic mean is a measure of the average diameter of grains in the sediment. The mean grain size in a deposit is largely controlled by energy of sediments transportation and deposition. The mean values were used for classification of sandstones as it describes the average grain size of the sediments. The mean values obtained range from (-0.40ϕ to 1.6ϕ) averaging 0.61ϕ. These values correspond to the mean range values proposed by Folk and Ward (1957) and indicate a very coarse grained to medium grained sandstone.

Therefore, the coarse conglomeratic sandstone sediments observed were associated with high energy conditions in which smaller grains were washed away leaving the coarse, pebbly grains that were too heavy due to gravity to be carried away by water current. Such sediments are suggested to be within the proximal, upper course of a river regime. On the contrary, the medium grained sediments are suggested to have been carried further down the river channel at a relatively lower energy of transportation (distal facies).

Sorting

Sorting is a measure of uniformity in grain size distribution. It can also be defined as the degree of sediment arrangement as well as the grain size distribution and it corresponds with the standard deviation. Through sorting, textural maturity of sediments can be determined. This textural maturity gives an indication of the depositional medium and transportation history of grains according to their size. These parameters are indicative of hydrodynamic condition, range of violence and degree of turbulence operating in the transport medium. Sorting of sediment is dependent on the sediment source, grain size and depositional mechanism.

The statistical calculation indicated sorting values range from (-0.08 ϕ to 1.8 ϕ) averaging 1.03 ϕ which implies that the sediments are poorly sorted. From sorting classification by Folk and Ward (1957), values within the range of (< 0.35ϕ) are very well sorted while the sorting class that falls between the range of (1.0ϕ to 2.0ϕ) represents samples that are poorly sorted. Since sorting is a reflection of distance of transportation, energy and environment of deposition, it can be deduced that the sandstones are at proximal distance from their source and transported by low energy that did not permit hydraulic sorting and probably associated with minimal current activities and quick deposition. The poor sorting are typical of river deposited sediments because river velocities are very variable at different times.

Skewness

Skewness measures symmetry in the scatter of a distribution as well as the degree of lop-sidedness of a curve and it reflects the depositional process. Beach sands, for example, tend to have a negative skewness because finer components are carried off by persistent wave action. River sands are usually positively skewed, because much silt and clay are not removed by the currents, but are trapped between larger grains. The sandstones analysed show skewness range of (-0.26**ϕ** to 3.7**ϕ**) averaging 0.53**ϕ** with ten (10) out of the nineteen (19) samples being finely skewed. The predominating fine skewness value indicates positive skewness which is typical of river sands.

Kurtosis

Kurtosis value measures the peakedness of a curve from normal. It describes the departure of the distribution from the normality by comparing the sorting of the tails with the central portions. The kurtosis values range from -0.98ϕ to 2.2ϕ, averaging 0.76ϕ. The grain size analysis shows that the sandstones are platykurtic.

3.3 Petrographic analysis

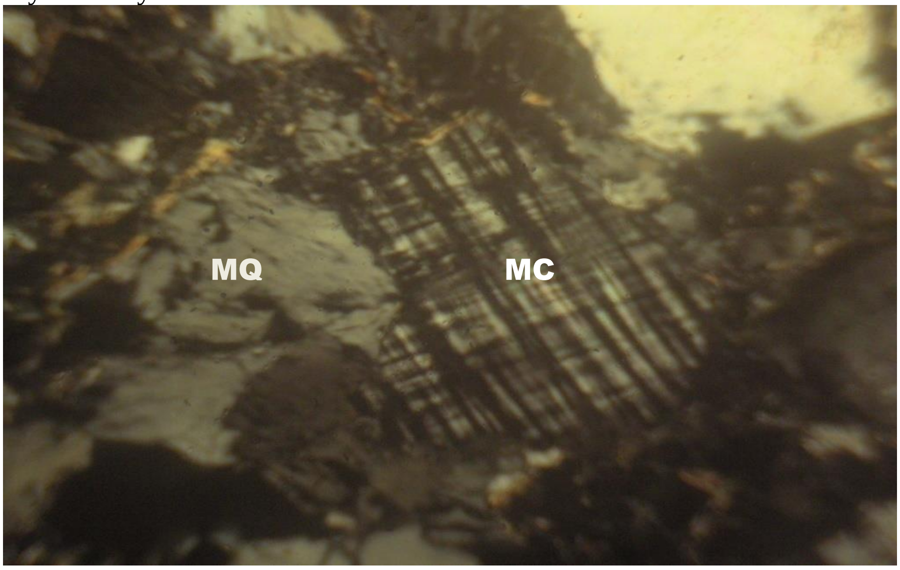
The objective of the petrographic study was to establish a baseline information on the petrological characteristics of minerals observed in the sandstones of Lokoja Formation exposed in the study area. This was accomplished by identification of the characterizing minerals and other components present in the thin sections of the sandstone.

Thin section study was carried out on ten sandstone samples to determine the mineralogical composition and textural maturity of the mineral grains. The minerals observed in the samples include quartz, feldspar (plagioclase and microcline), mica (muscovite and biotite) in varying proportion.

The quartz minerals observed are generally subhedral with a lot of polymodal fractures. It also exhibits wavy extinction, low birefringence and a low relief. In all the sandstone samples analyzed, quartz (especially monocrystalline) is the dominant mineral because of it stable nature Plate 1a and Plate 1b. Feldspars observed is dominantly microcline that is subhedral, colourless, with low relief and weak birefringence. It surfaces exhibit the cross-hatch twinning pattern, which are often altered. The mica group present has very low percentage and occurs as biotite and muscovite. The muscovite observed is colourless with moderate relief, strong birefringence and straight extinction. Biotite occurs as brown mineral with perfect basal cleavage in one direction, moderate relief, strong birefringence and straight extinction Plates 1a and 1b. Table 2 shows the percentage distribution of the mineral compositions in the sandstone samples.

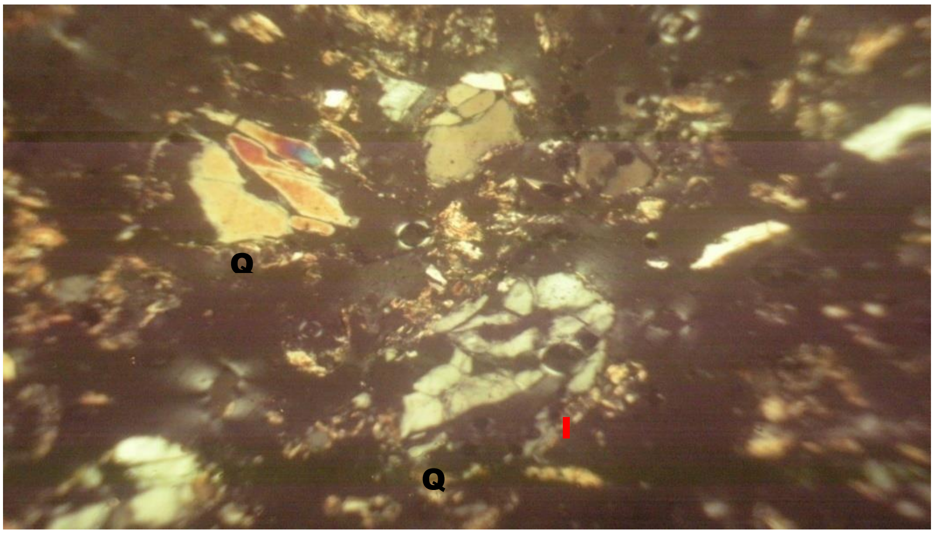
Table 2: Percentage (%) mineral composition of the sandstone samples from the study area

Sample no.	Quartz		Feldspar		Biotite	Muscovite
	Monocrystalline	Polycrystalline	Microcline	Plagioclase		
FEJ 3A	75	10	10	3	2	-
FEJ 4A	80	8	5	5	2	
FEJ 5A	78	7	7	6	2	
FEJ 6	85	5	3	4	2	1
FEJ 7	80	7	10	-	2	1
FEJ 8A	80	6	4	5	3	2
FEJ 8C	88	4	6	-	2	-
FEJ 9	88	2	-	6	4	-
FEJ 10A	85	5	3	-	3	-
FEJ 3C	88	6	3	-	3	



MQ= Monocrystalline quartz MC= Microcline feldspar

Plate 1a: Photomicrograph showing mineral composition of FEJ-9 under cross polarize (XP)



Q= Quartz I= Inclusion

Plate 1b: Photomicrograph showing mineral composition of FEJ-9 under cross polar (XP)

3.4 Interpretation of Depositional Environment

Depositional environment is the totality of the complex wide variety of depositional conditions (physical, chemical and biological) under which sedimentary rocks can accumulate. The lithology of a clastic sediment is a function of the environment in which it was deposited, its transportational history and the type of rock from which it was derived. Textural maturity is linked to the environment of deposition by Folk (1974). Evidence from textural analysis shows that the sediments are sub-angular to angular in shape, poorly sorted, medium to coarse grained which indicates less winnowing and abrasion caused by rapid deposition and short distance of transportation reflecting a fluvial setting. The results of skewness and sorting measures (Table 1) reflect that the sediments are positively skewed and poorly sorted grains which indicates river sands according to Friedman (1979). Kurtosis plots indicate a range from platykurtic to leptokurtic. The presence of feldspar and clay matrix support in most of the sediments indicate that the sediments are texturally and mineralogically immature. Also, the occurrence of thin ferruginous beds discontinuously within the sandstone beds were as a result of oxidation of primary sediment particles containing ferrous ions and manganese which were subsequently partially replaced by oxyhydrates of iron and manganese (e.g. limonite, FeOOH). The iron minerals were later transformed into hematite forming coating around larger grains. The iron minerals served as cement for the sand grains.

The fluvial setting of the sediments was further confirmed by the bivariate plots of the grain size parameters (Fig. 6a-c). The use of bivariate plots of the grain size parameters in environmental discrimination was based on the assumption that the statistical parameters reliably reflect differences in the fluid- flow mechanisms of sediment transportation and deposition (Sutherland and Lee, 1994). On this basis, the plot of mean values against sorting values, skewness values versus sorting values and skewness values against kurtosis values as shown in (Fig. 6a-c) reflect a fluvial setting. Also, using the discriminate function (Y3) proposed by Sahu, 1964 and as used by Alsharhan and El- Sammak, 2004 gives the discrimination between fluvial and shallow marine

$$\boxed{Y3 = 0.2852\, MZ - 8.7604\, \delta^2 - 4.8932\, SK + 0.0482\, KG}$$

where Y3 is the discriminate function between fluvial and shallow marine environments, MZ is the mean value, δ is the standard deviation or sorting value, SK is the skewness value, and KG is the kurtosis value. If Y3 is less than -7.419, the sample is identified as a fluvial (deltaic) deposit, and if greater than -7.419, the sample is identified as a shallow marine deposit. Therefore, using the mean values, sorting values, skewness values and kurtosis values as given above, the following results were obtained for Y3 as summarized in Table 3.

Table 3: Summary of discriminate function (Y3) of grain size parameters

sample no,	FEJ-1	FEJ-3A	FEJ-3B	FEJ-4A	FEJ-4B	FEJ-5A	FEJ-5B	FEJ-6	FEJ-7	FEJ-8A	FEJ-8B	FEJ-8C	FEJ-8D	FEJ-9	FEJ-10A	FEJ-10B	FEJ-10C	FEJ-10D	FEJ-10E
Y3	-19.9	-10.5	-10.8	-9.9	-29.8	-8.6	-25.9	-28.2	-12.2	-9.6	-9.2	-7.5	-9.7	-13.5	-18.5	-18.9	-4.9	-2.6	-2.7

From Table 3, about 84% of the values of Y3 are less than (-7.419) which also confirms the fluvial environment for the sediments.

Therefore, according to Guiraud (1990) and Ojo (1999) the conglomerates (with poor sorting, non-imbricated clasts and lack of sedimentary structure) in the upper Benue Trough have been interpreted as gravity induced alluvial fan deposits. The presence of unidirectional paleocurrent pattern displayed by the preferred orientation of the pebbles in a North-Eastern direction, absence of trace fossils (Ophiomorpha and Thalassinoides), presence of alternating thick sequence of conglomeratic sandstone and pebbly to coarse grained sandstones and overbank fine sediments in the studied area all indicates the braided fluvial origin. This was also in agreement with the works of Amireh and Abed (1999); Brown and Plint (1994) and Rust and Jones (1987)

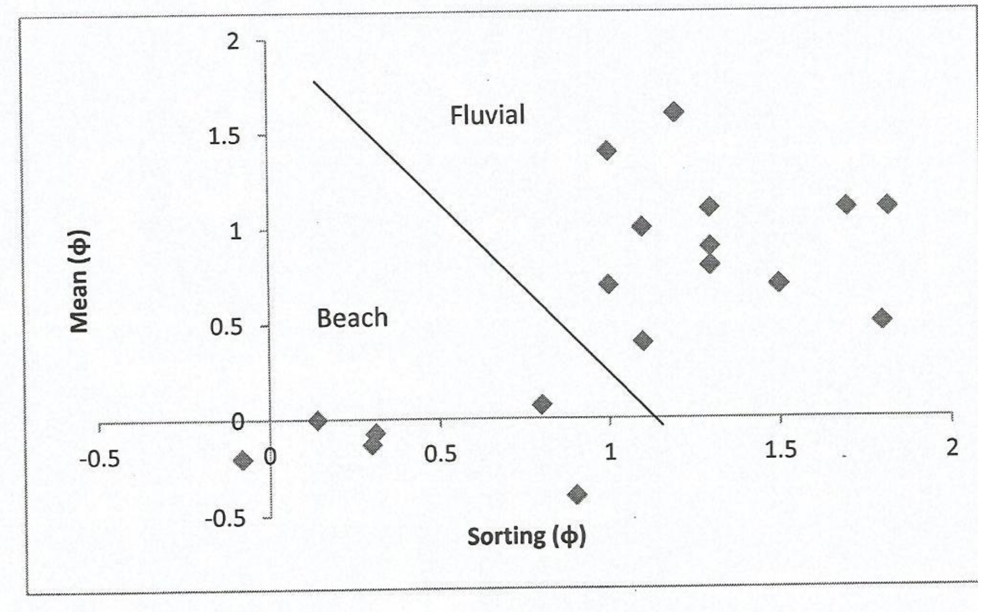


Figure 6a: The plot of Mean against Sorting

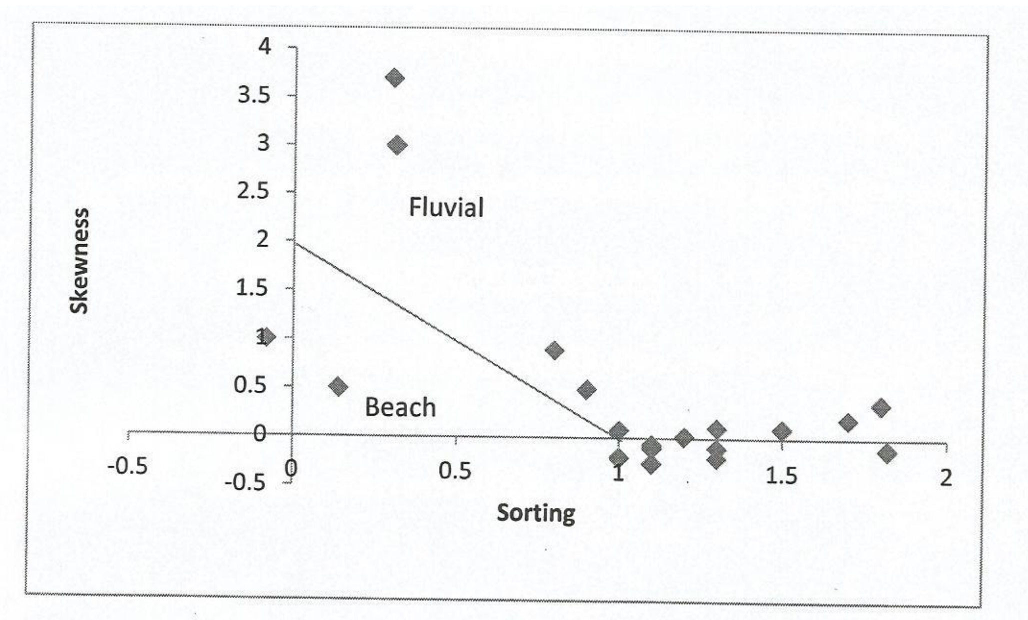


Figure 6b: The plot of Skweness against Sorting

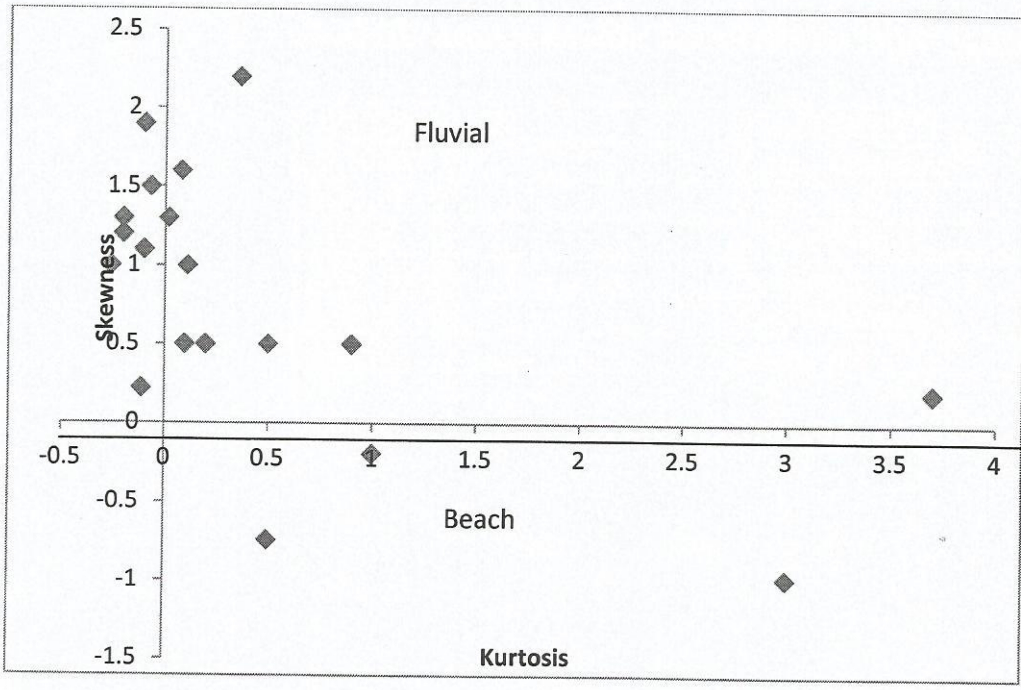


Figure 6c: The plot of Skewness against Kurtosis

3.4 Heavy Mineral Analysis

Heavy minerals are accessory mineral constituents of siliciclastic sediments which serve as pointer to sediments provenance and events in the source area. Four selected sandstone samples were used for the heavy minerals analysis. Fig. 7a and Fig. 7b show the photomicrographs of the heavy minerals thin sections and the result of percentage modal compositions is as shown in the Table 4

Table 4: Percentage composition of heavy mineral for Lokoja Formation exposed at Felele Junction

Mineral	FEJ-3A	FEJ-4A	FEJ-8D	Optical properties
Staurolite	85	75	71	Yellow to pale yellow crystal that is plechroic containing quartz inclusions
Opaque	10	10	10	Dark minerals that remain dark even during stage rotation
Zircon	-	10	8	Colorless with sub-rounded grains in thin section and exhibit high birefringence due to high polarization
Tourmaline	2	-	-	Black usually, but green, reddish colour on rotation with good prismatic cleavage
Rutile	3	5	8	Euhedral crystal that is yellow-reddish in colour
Kyanite	-	-	2	Colourless and pale blue on rotation of stage
Sphene	-	-	1	Occur as four-sided crystal that is brownish in colour

In the petrographic study of the sandstones, quartz is the dominant constituent mineral followed by feldspar. The average frame work composition of the mineral constituents present are shown below

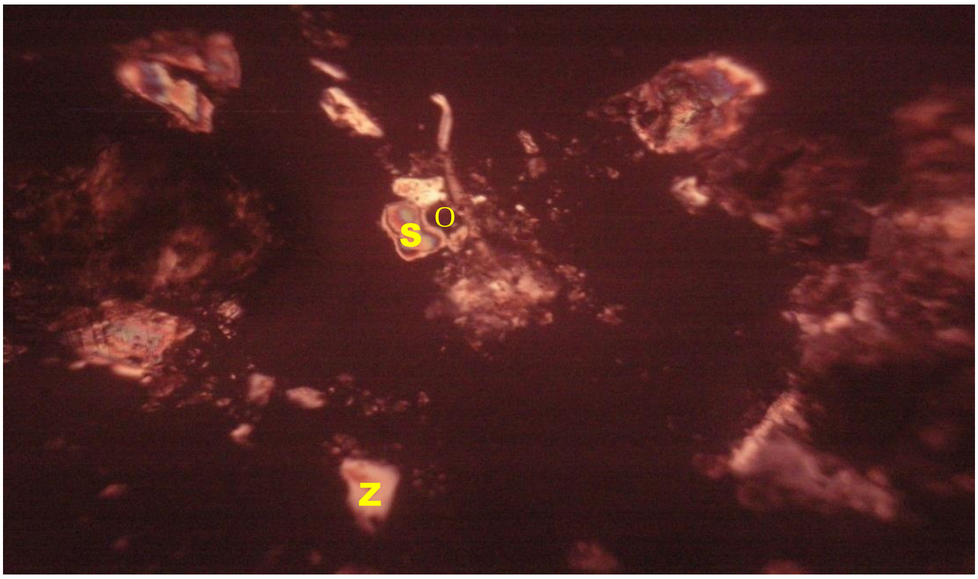
Average framework composition of Lokoja Formation

Quartz (monocrystalline + polycrystalline)	89.6%
Feldspar (microcline + plagioclase)	8.2%
Biotite	2.6%
Muscovite	0.2%

Therefore, based on the work of Pettijohn (1975) on sandstone classification as shown in Fig. 8, the sandstones of Lokoja Formation can be classified as subarkose, which also confirms sediments deposited in continental environment.

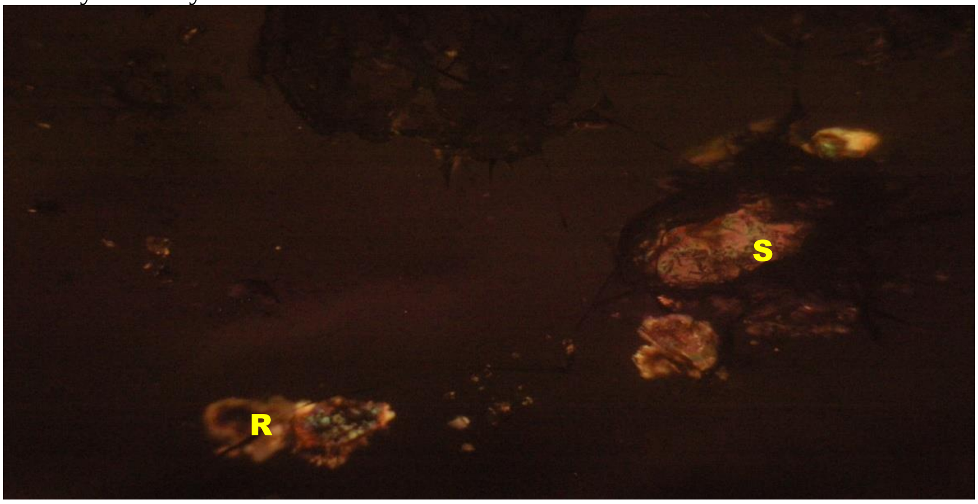
The heavy minerals present reveal a non-opaque mineral suite including staurolite, tourmaline, rutile, kyanite, zircon, sphene and opaque minerals. These heavy mineral suites occur as detrital grains in the samples which indicates that, the sediments were derived from the basement complex of igneous and metamorphic rocks Feo-Codecido (1956); probably the Southwestern Precambrian domain. The dominating staurolite occurs in regionally metamorphosed rock showing a low-grade metamorphism. Therefore, staurolite, rutile and kyanite are derived from metamorphic rocks like gneisses, schist etc. The zircon, tourmaline, sphene and opaque minerals are typical of igneous rock source like granite, pegmatite etc. The occurrence of noticeable amount of heavy minerals from the sediments indicates that they are probably of younger age (Pettijohn, 1975) because of less intrastratal dissolution.

Furthermore, based on the work of Dickinson *et al.* (1983), the subarkose sandstone of Lokoja Formation have rifted and uplifted continental block provenance. Also, the framework components of the sandstones are genetically linked to the geodynamic environment of the source area. Subarkose characterized by abundant fresh feldspars are typical of high relief and uplifted source where sediments shed from faulted and uplifted basement rocks are deposited proximally without much transportation (Amajor, 1990).



O= Opaque mineral **S= Staurolite** **Z= Zircon**

Figure 7a: Photomicrograph showing mineral compositions (heavy minerals) of FEJ-8D under cross polar (XP)



R= Rutile **S= Staurolite**

Figure 7b: Photomicrograph showing mineral compositions (heavy minerals) of FEJ-8D under cross polar (XP)

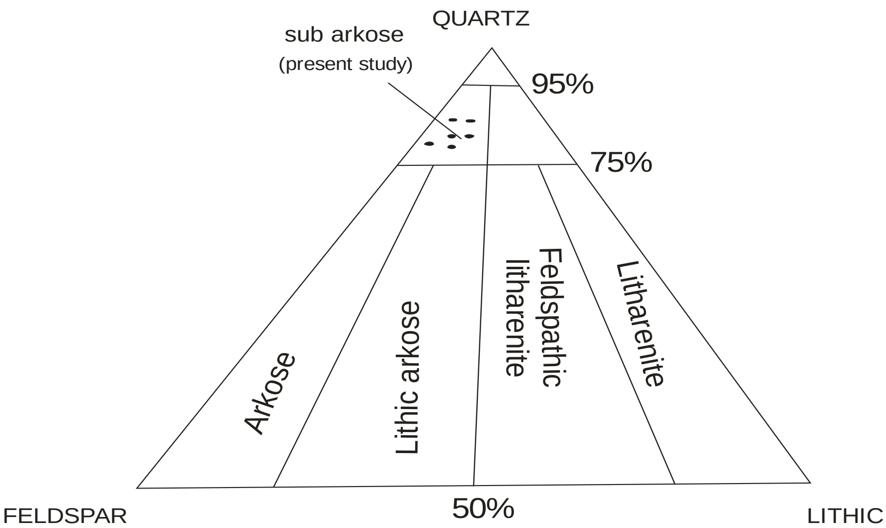


Figure 8: Classification of Lokoja sandstone using the QFL ternary diagram (after Pettijohn, 1975)

Q = Quartz, F = Feldspar, L = Lithic

4. Conclusion

The Campanian Lokoja Formation exposed at Felele Junction about 1km north of NATACO Junction was investigated. Fieldwork coupled with laboratory analyses were used in the determination of paleodepositional environment of the sediments. The total thickness of the section exposed is approximately 21.48m.

Nineteen sandstone samples were subjected to the grain size analysis using the mechanical sieve shaker. The results of the grain size analysis was used in the determination of the grain size parameters (mean, sorting, skewness and kurtosis) and reveal that the sandstones in the study area are very coarse to medium grained, poorly sorted, positively skewed and leptokurtic to platykurtic in nature indicating that the sediments are at proximal distance from the source and have characteristics of river deposited sediments. The plots of mean against sorting, skewness against sorting and skewness against kurtosis indicate a fluvial setting for the sediments. The cumulative curves for the sandstones suggest traction, saltation and suspension as the possible mechanisms of sediment transport while grain size frequency histograms show unimodal to bimodal asymmetric grain size distribution pattern with shifting modes that indicate variation in the energy of the current that deposited the sandstones.

Heavy mineral study of selected sandstones revealed non-opaque and opaque mineral suite. The non-opaque minerals identified under petrological microscope were staurolite, zircon, tourmaline, rutile, kyanite and sphene. The heavy mineral suites indicate that the sediments were derived from basement complex of igneous and metamorphic rocks. Petrographic study shows the presences of quartz (monocrystalline and polycrystalline), feldspar (microcline and plagioclase) and mica (muscovite and biotite). The sandstones in the study area are mineralogically immature and classified as subarkose.

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