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Sedimentology and Petrographic Studies of Ogun River Bridge Sediments, Dahomey Basin, Southwestern Nigeria

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ABSTRACT

This study examined the sedimentological and petrographic characteristics of the Ogun River bridge sediments around the Dahomey Basin, Southwestern Nigeria. A cumulative frequency curve was obtained by plotting grain size (Phi (ɷ)) versus cumulative percentage. The phi values at 5%, 16%, 25%, 50%, 75%, 84%, and 95% percentages were read from the plotted o-give curve. Gravimetric analysis was conducted on five samples collected from Ogun River to determine sediment sedimentology and depositional environment. Grain-size analysis results indicate that Ogun River sediment is poorly to very poorly sorted, and coarse to very coarse-grained in texture indicating less winnowing and abrasion. Six (6) specimens are analyzed under thin sections. The result shows the heavy minerals composition of the River Ogun sediments have high proportion of Zircon and Staurolite compared to Rutile in the sediment. In conclusion, the sequence of the sediments comprises fluvial to marine-dominated sediments which are proximal to distal from the source, sourced from both igneous and metamorphic origin, mineralogical mature, texturally immature to mature, and are formed under warm and humid conditions.

Keywords: Sedimentology; Petrographic; Mineralogy; Depositional environment; Granulometric analyses; Thin sections; Dahomey Basin.

1. Introduction

The Dahomey basin is a sedimentary basin formed without any volcanic activity, it is a mix of inland, coastal, and offshore basins expanding from southern Ghana, through Togo and Benin, to southwestern Nigeria. The Okitipupa Ridge acts as a barrier between the Niger Delta. Its boundaries in the ocean are unclear. Sediment accumulation occurs in an east-west orientation [1]. Cretaceous strata on land measure around 200m in thickness [2]. A basal sequence without fossils is formed on top of the Precambrian basement.

Following this, there are sequences of coal, clay, and marl layers that include horizons with fossils. A report has been made about a thick 1,000m sequence offshore, which includes sandstones at the bottom and black fossiliferous shale at the top. Study in [3] dated this as occurring before the Albian and after the Maastrichtian. The Cretaceous period is separated into two regions, one in the north and one in the south. The northern area features a succession of sand at the base transitioning into layers of clay with deposits of lignite and shale interspersed.

The highest layers of the Maastrichtian consist mainly of clay. The stratigraphy in the southern zone is more complex, with marl and limestone beds making up the main facies [4]. The western boundary of the basin is defined by faults and other tectonic structures connected to the inland continuation of the fracture zone. The hinge line also serves as the boundary on the Eastern side as it marks the western edge of the Niger Delta [5]. It is also bounded in the north by Precambrian basement rock and the bright of Benin in the south. The basin fill covers a broad arc-shaped profile, attaining about 13km maximum width onshore at the basin axis along the Nigeria and the Republic of Benin boundary. This narrows westwards and eastwards to about 5km [6].

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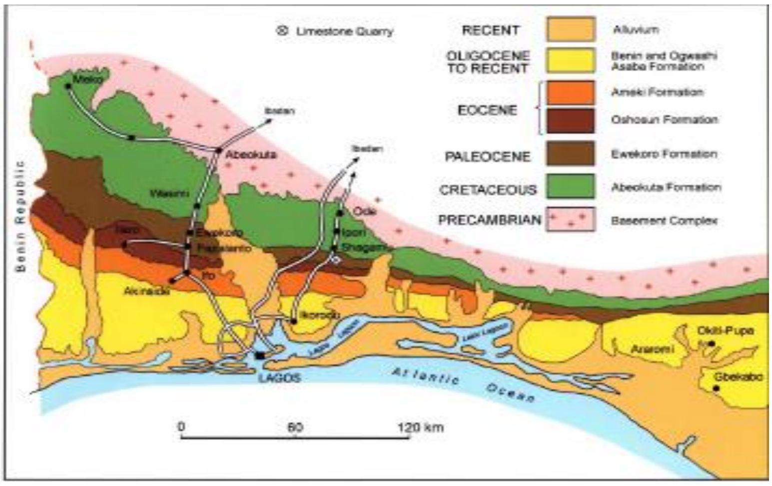

Figure 1. The Dahomey embayment map (Nigeria part)

This paper aims to study the sedimentological characteristics and evaluate the textural characteristics, mineralogy, and depositional environment of the sediment exposed at Ogun River Bridge in the Dahomey basin.

1.1. Study Objectives

The objectives are to observe the petrographic characteristics of the sediments and assess the heavy mineral composition of the sediments to interpret the depositional environment.

2. Location of the Study Area

The Ogun River can be found between latitudes $6^0$33'N and $8^0$8'N and longitudes $2^0$40'E and $4^0$10'E (Figure 2). The watershed covers approximately 23,000 square kilometers. The Ogun River originates from the Iganran hills, located at a height of roughly 530m above sea level, and travels in a southerly direction for approximately 480km until it empties into the Lagos lagoon. The study identifies the lower River Ogun as the section from Mokoloki town to Isheri town downstream, specifically areas with sedimentary, Abeokuta formation characterized by medium to coarse grain sandstone that is poorly sorted and micaceous [7]. Clay and mudstone layers are present, with frequent crossbedding and a soft, crumbly texture, except in areas where iron-rich materials have hardened the rock locally [8]. The primary sedimentary rocks consist of Quaternary-age alluvial deposits and coastal plain sands.

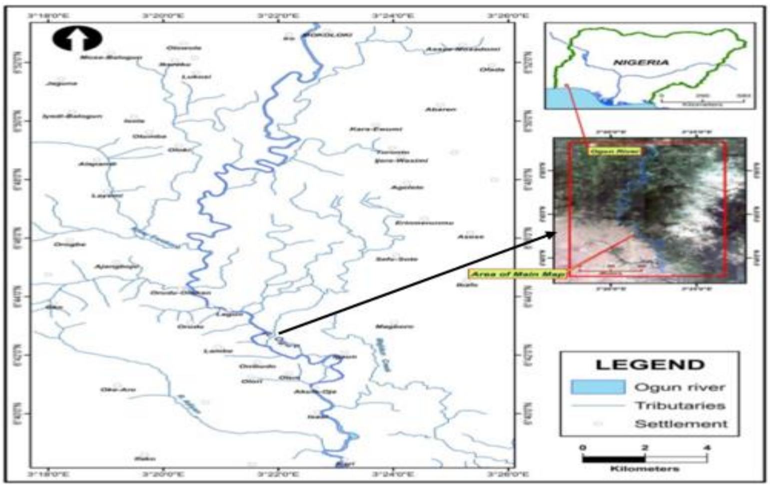

Figure 2. Map showing the study area with Pointed Arrow (Google map)

3. Methodology

Grain size analysis is carried out on five samples to deduce the distribution of the sample grain size, the apparatus used includes the sieve shaker and weighing balance. 100g of each sample was measured out and subjected to standard grain size analysis using a set of sieve sizes ranging from 2.00mm, 1mm, 0.75mm, 0.6mm, 0.5mm, 0.35mm, 0.3mm, 0.25mm, 0.212mm, 0.075mm, 0.063mm. The electric sieve shaker was used to agitate and activate the sieving process for ten minutes. The sieves were arranged such that the screen with the smallest opening (0.063mm) was at the base and the largest (2.00mm) at the top. The pan was placed below the 0.063mm sieve. The fraction left in each sieve and in the pan was measured, which is used for statistical calculations. The percentage of the aggregates was estimated. This basic data i.e. weight percentage frequency data is converted into cumulative weight percentage. The cumulative curves constructed based on eight percent data served as a basic tool for the generation of other statistical parameters. The grain size of the 5^{th}, 16^{th}, 50^{th} 84^{th}, and 95^{th} percentile was obtained from each cumulative curve drawn.

Six samples of sandstone were analyzed for heavy minerals. Heavy liquid separation was carried out by settling out of the sample in a glass funnel. The funnel was partly filled with tetrabromoehane (SG=2.97) with the sample poured in. The mixture was stirred and observed until heavy minerals could no longer be seen to settle in the stem of the funnel. A small funnel with filter paper was placed under the holding funnel and the accumulated heavy minerals dropped in. The filter paper holding the heavy minerals was then made to dry under the sun before being placed under the transmitted light microscope for petrographic study.

4. Result and Discussion

4.1. Grain Size Analysis Result

The grain size analysis was carried out on five carefully selected samples, OG. RB01 to OG. RB05. A table composed of sieve size diameter, phi, weight retained (g), percentage weight retained (%), cumulative weight retained (g), percentage cumulative weight retained (%), cumulative curve, and histogram chart was made for each sample. The results of the grain size analysis show that the River Ogun sediments are poorly sorted to very poorly sorted, coarse to very coarse-grained in texture indicating less winnowing and abrasion [7],[8].

Table 1. Grain size data of sample OG. RB01

Sieve Size (mm)	Phi (ø)	Individual Weight Retained (g)	Individual Weight Retained (%)	Cumulative Weight (g)	Cumulative Weight (%)
1.18	-0.2	29.83	30.49	29.83	30.49
1.00	0.0	0.64	0.65	30.47	31.15
0.71	0.5	7.79	7.96	38.26	39.11
0.60	0.7	31.35	32.05	69.61	71.16
0.50	1.0	8.17	8.35	77.78	79.51

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0.42	1.3	6.44	6.58	84.22	86.10
0.30	1.7	7.47	7.64	91.69	93.73
0.25	2.0	1.51	1.54	93.20	95.28
0.112	3.2	2.63	2.69	95.83	97.97
0.075	3.7	0.50	0.51	96.33	98.48
Pan	Pan	1.49	1.52	97.82	100.00

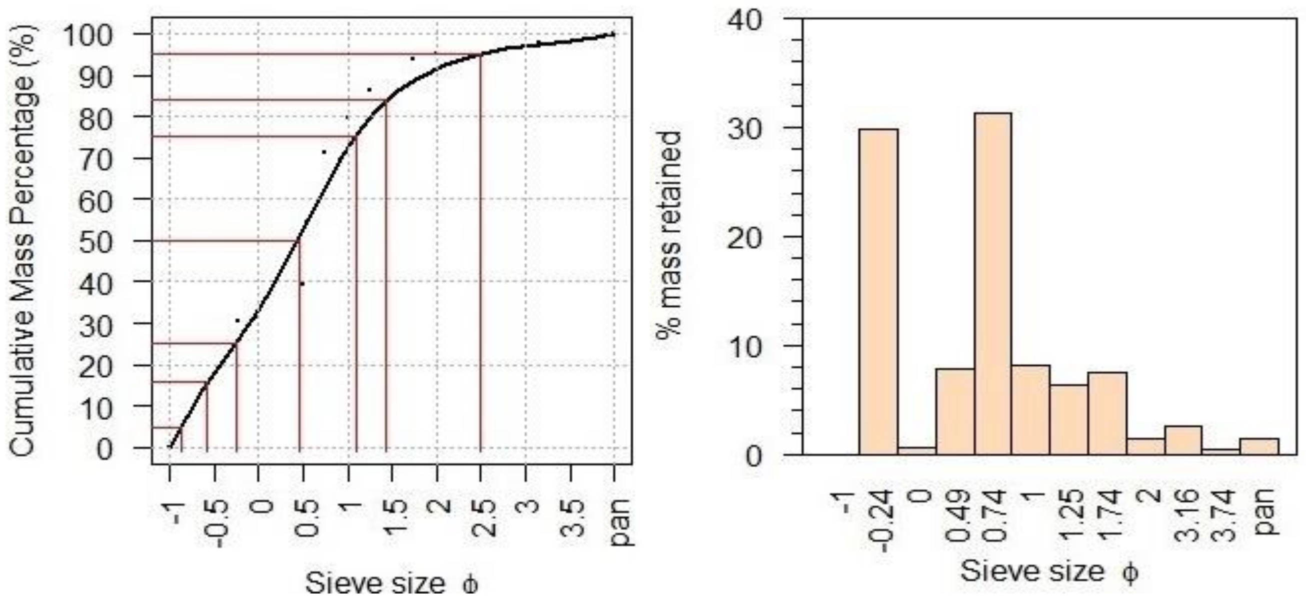

Figure 3. Cumulative Frequency and Histogram Curve for sample OG. RB01

Table 2. Grain size data of sample OG. RB02

Sieve Size (mm)	Phi (ø)	Individual Weight Retained (g)	Individual Weight Retained (%)	Cumulative Weight (g)	Cumulative Weight (%)
1.18	-0.24	38.30	38.41	38.30	38.41
1.00	0.00	0.16	0.16	38.46	38.57
0.71	0.49	3.49	3.50	41.95	42.07
0.60	0.74	26.99	27.07	68.94	69.14
0.50	1.00	7.85	7.87	76.79	77.01
0.42	1.25	3.79	3.80	80.58	80.81
0.30	1.74	12.25	12.29	92.83	93.10
0.25	2.00	2.65	2.66	95.48	95.76

0.112	3.16	2.78	2.79	98.26	98.55
0.075	3.74	0.44	0.44	98.70	98.99
Pan	Pan	1.01	1.01	99.71	100.00

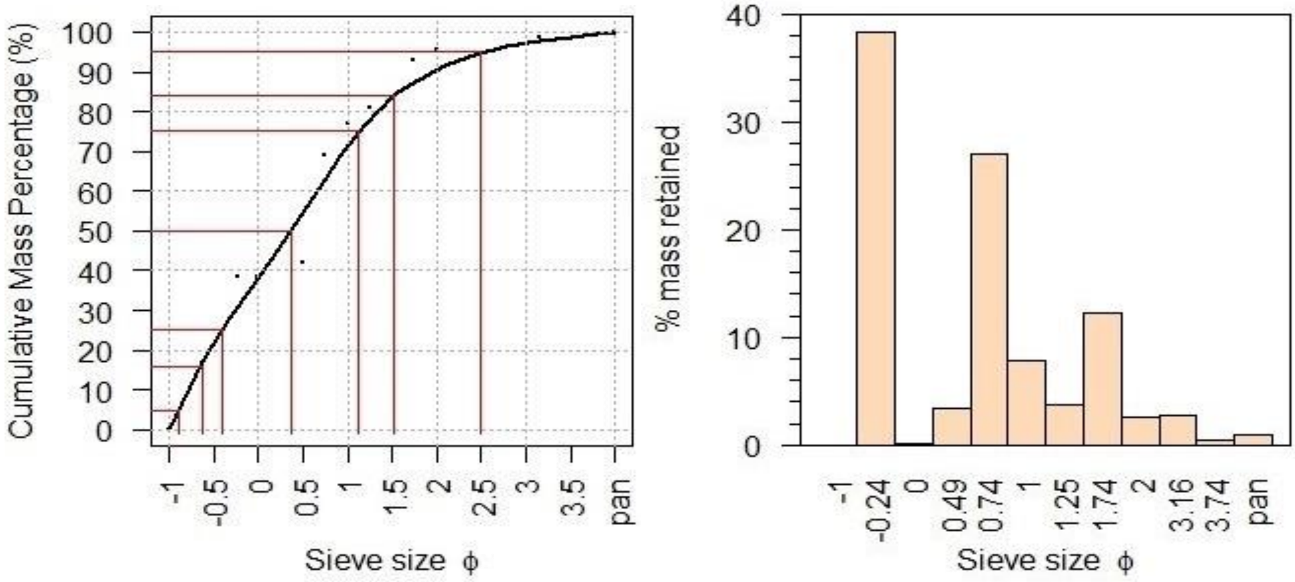

Figure 4. Cumulative Frequency and Histogram Curve for sample OG. RB02

Table 3. Grain size data of sample OG. RB03

Sieve Size (mm)	Phi (ɸ)	Individual Weight Retained (g)	Individual Weight Retained (%)	Cumulative Weight (g)	Cumulative Weight (%)
1.18	-0.24	45.01	45.25	45.01	45.25
1.00	0.00	0.50	0.50	45.51	45.76
0.71	0.49	4.33	4.35	49.84	50.11
0.60	0.74	16.43	16.52	66.27	66.63
0.50	1.00	5.29	5.32	71.56	71.95
0.42	1.25	1.03	1.04	72.59	72.98
0.30	1.74	12.36	12.43	84.95	85.41
0.25	2.00	4.63	4.66	89.58	90.07
0.112	3.16	7.16	7.20	96.74	97.27

0.075	3.74	1.03	1.04	97.77	98.30
Pan	Pan	1.69	1.70	99.46	100.00

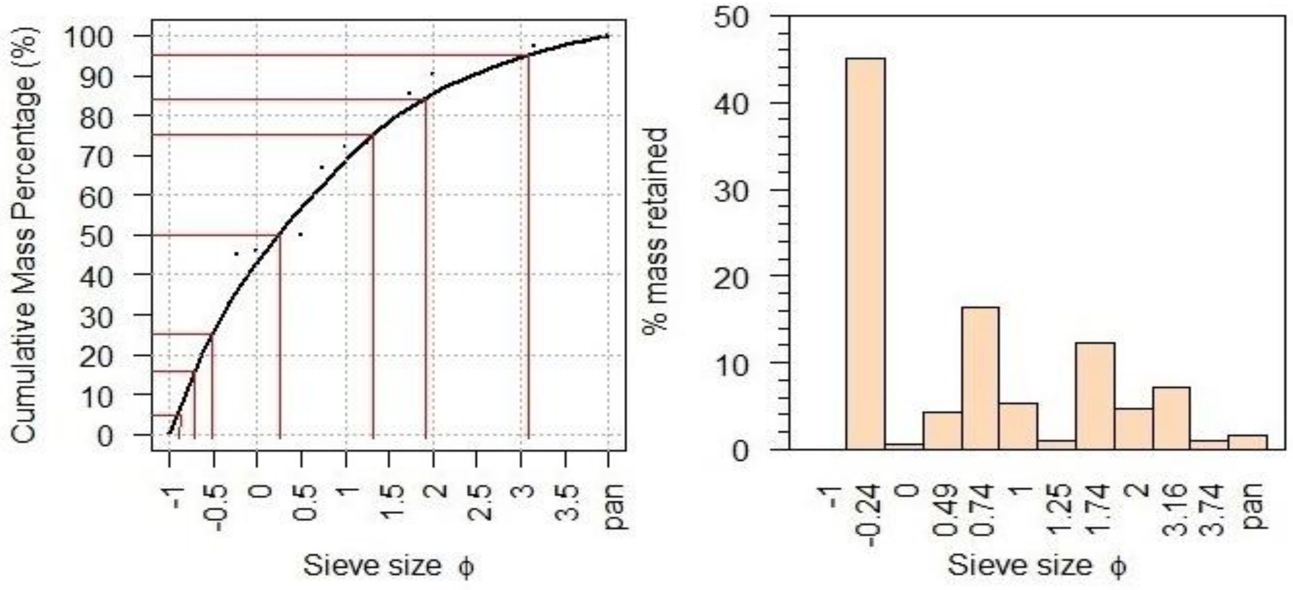

Figure 5. Cumulative Frequency and Histogram Curve for sample OG. RB03

Table 4. Grain size data of sample OG. REB04

Sieve Size (mm)	Phi (ø)	Individual Weight Retained (g)	Individual Weight Retained (%)	Cumulative Weight (g)	Cumulative Weight (%)
1.18	-0.24	64.57	65.07	64.37	65.07
1.00	0.00	0.44	0.44	65.01	65.51
0.71	0.49	2.43	2.43	67.44	67.96
0.60	0.74	13.73	13.84	81.17	81.80
0.50	1.00	2.22	2.24	83.39	84.04
0.42	1.25	1.69	1.70	85.08	85.74
0.30	1.74	6.05	6.09	91.13	91.83
0.25	2.00	2.40	2.42	93.33	94.25
0.112	3.16	3.75	3.78	97.28	98.03
0.075	3.74	0.67	0.68	97.95	98.71
Pan	Pan	1.28	1.29	99.23	100

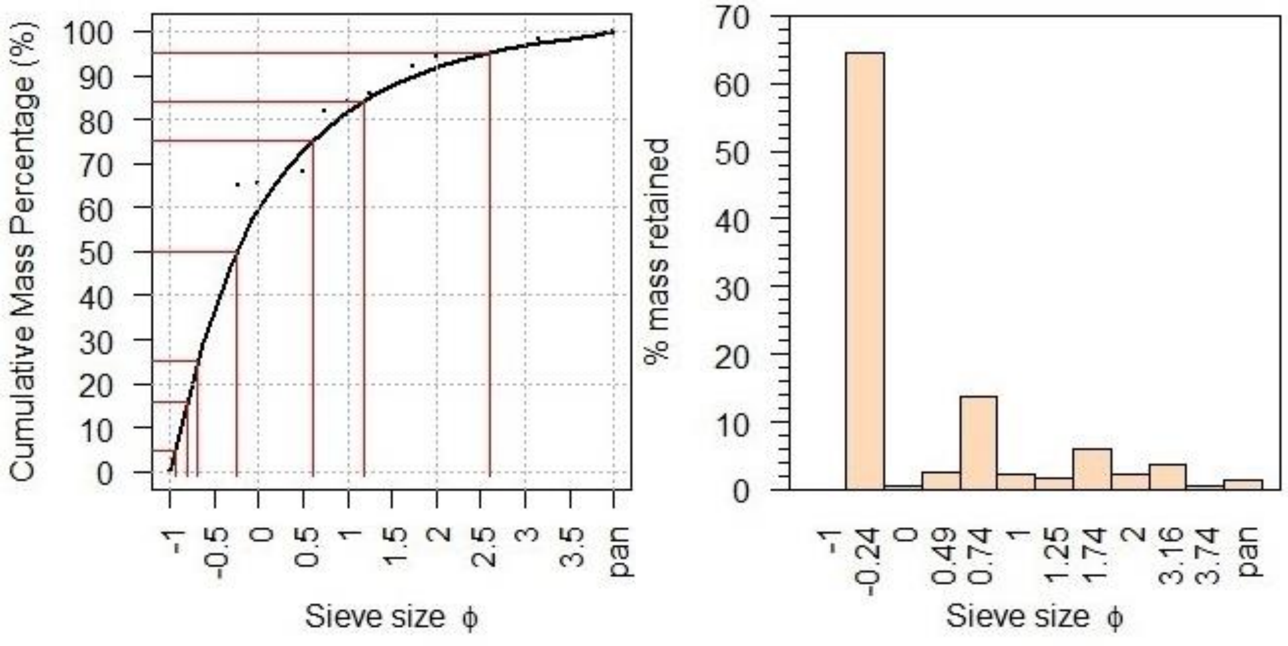

Figure 6. Cumulative Frequency and Histogram Curve for sample OG. RB04

Table 5. Grain size data of sample OG. RB05

Sieve Size (mm)	Phi (ø)	Individual Weight Retained (g)	Individual Weight Retained (%)	Cumulative Weight (g)	Cumulative Weight (%)
1.18	-0.24	37.41	38.41	38.30	38.41
1.00	0.00	0.25	0.16	38.46	38.57
0.71	0.49	4.97	3.50	41.95	42.07
0.60	0.74	26.30	27.07	68.94	69.14
0.50	1.00	6.55	7.87	76.79	77.01
0.42	1.25	1.32	3.80	80.58	80.81
0.30	1.74	13.82	12.29	92.83	93.10
0.25	2.00	2.65	2.66	95.48	95.76
0.112	3.16	4.09	2.79	98.26	98.55
0.075	3.74	0.55	0.44	98.70	98.99
Pan	Pan	1.44	1.01	99.71	100.00

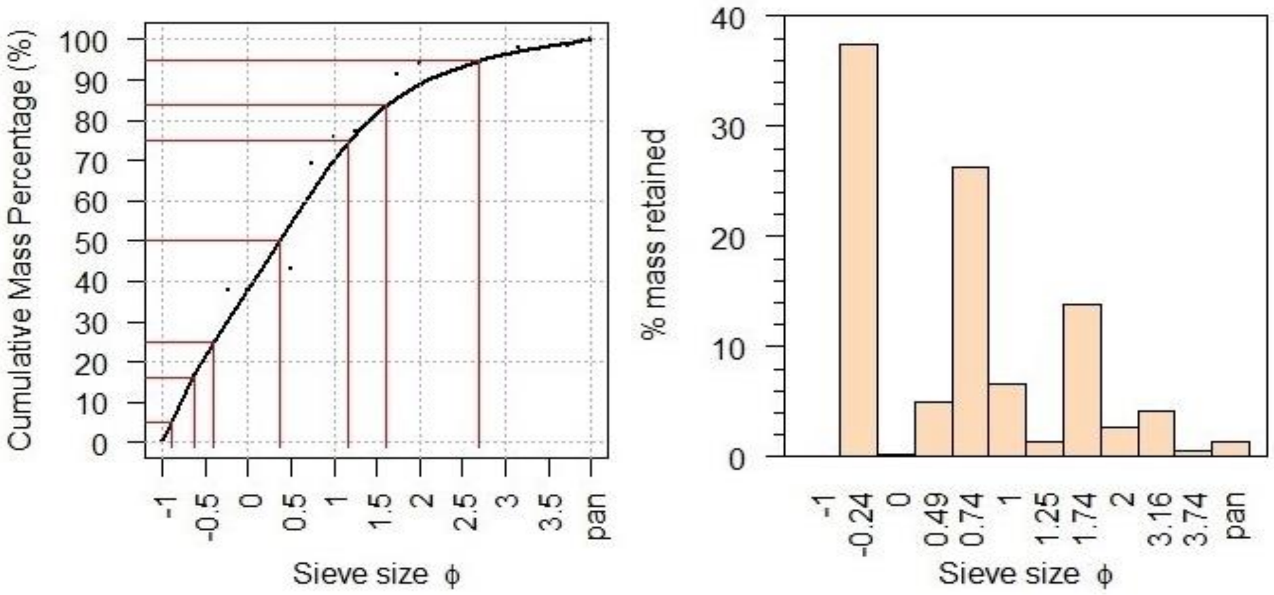

Figure 7. Cumulative Frequency Curve and Histogram plot for sample OG. RB05

4.2. Heavy Mineral Results and Interpretation

Heavy minerals in placer deposits typically form in beach settings through concentration caused by the mineral grains' specific gravity. There is an equal likelihood of finding certain amounts of heavy minerals in streambeds, yet the majority are of low quality and small in size [9],[10]. The origin of heavy minerals is within the hard rock formations found in the erosion-prone areas of rivers that transport sediment to the ocean, where it becomes part of littoral drift. Sometimes, rocks are eroded by waves, causing debris to be carried in littoral drift and deposited on beaches where lighter minerals are separated. The origin rock supplies the dense minerals that dictate the makeup of the valuable minerals [11].

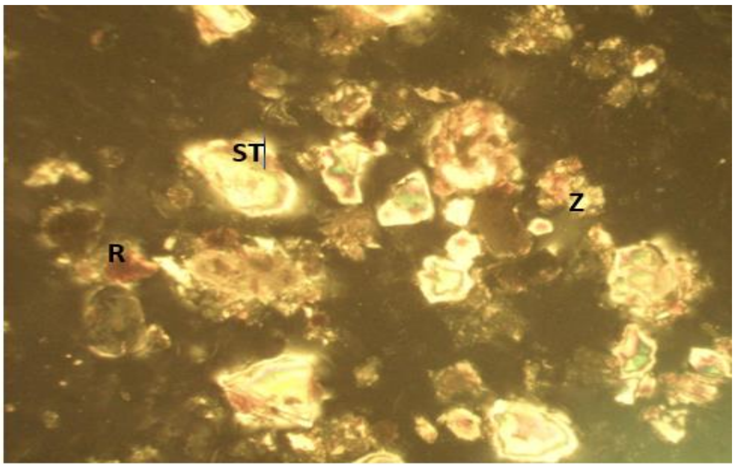

Figure 8. Photomicrograph of sample OGBR 4A xpl2 in crossed polarized light

Z= ZIRCON, ST=STAUROLITE and R= RUTILE

Staurolite is a red to brown mineral, mostly opaque, with a white streak, composed of nano-silicates. It forms in the monoclinic crystal system and has a mohr hardness rating of 7 to 7.5. Staurolite is a mineral that is utilized in determining the temperature, depth, and pressure during rock metamorphism. The color of rutile is reddish brown, it is primarily found in granites, pegmatite, and metamorphic rocks as a titanium oxide mineral [12],[13]. It is in sands formed from the erosion of these rocks. Rutile is a frequently found mineral in the alluvial sand that is mined for magnetite and ilmenite. Rutile is utilized in creating pigment for paint. Zircon is a highly stable dense mineral that is often found in acidic and intermediate parent rocks. Zircon is distinguishable by its very high relief, typically appearing colorless with a white interference color.

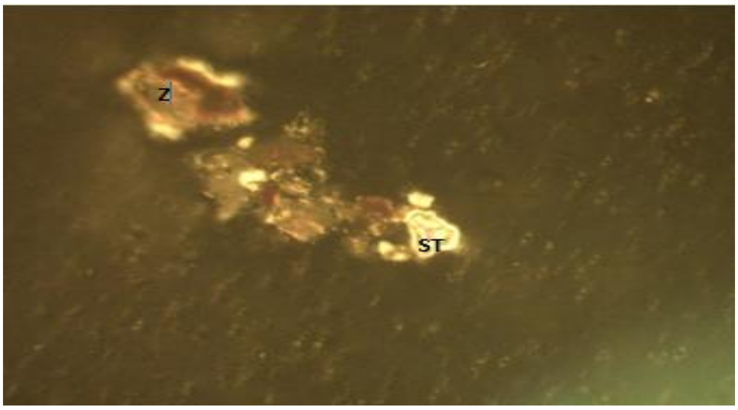

Figure 9. Photomicrograph of sample OGBR 5B xpl1 in crossed polarized light

Z= ZIRCON and ST=STAUROLITE

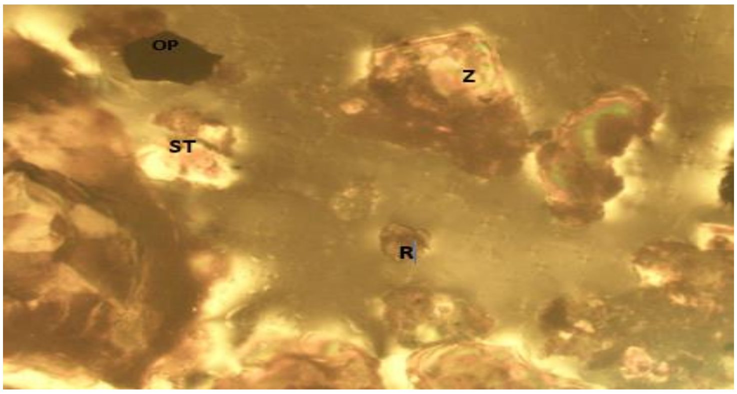

Figure 10. Photomicrograph of sample OGBR 2A ppl1 in crossed polarized light

Z= ZIRCON, ST=STAUROLITE and R= RUTILE

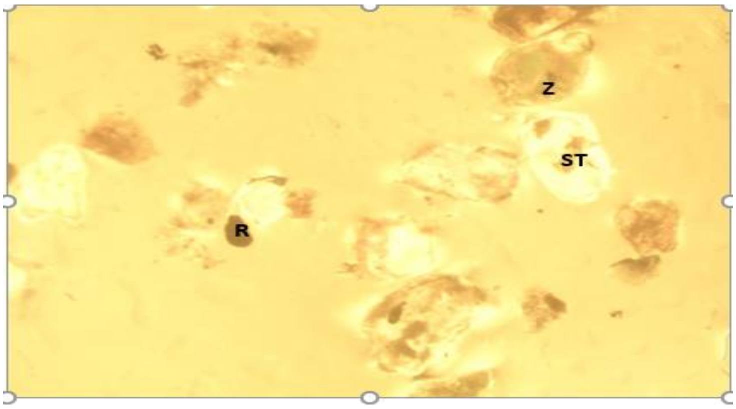

Figure 11. Photomicrograph of sample OGBR 4A ppl1 in crossed polarized light

Z= ZIRCON, ST=STAUROLITE, R= RUTILE

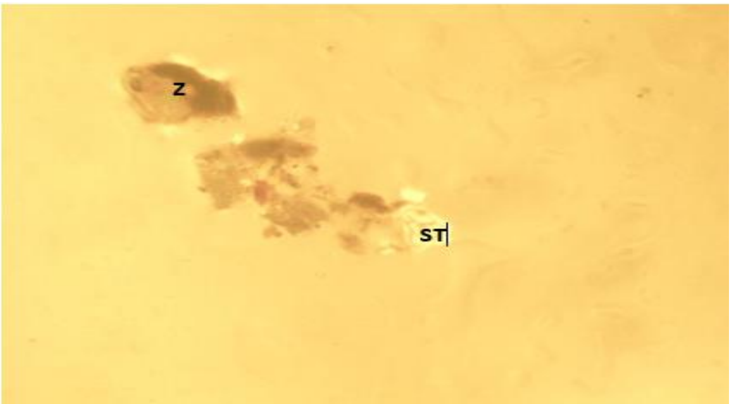

Figure 12. Photomicrograph of sample OGBR 5B ppl1 in crossed polarized light

Z= ZIRCON, ST=STAUROLITE

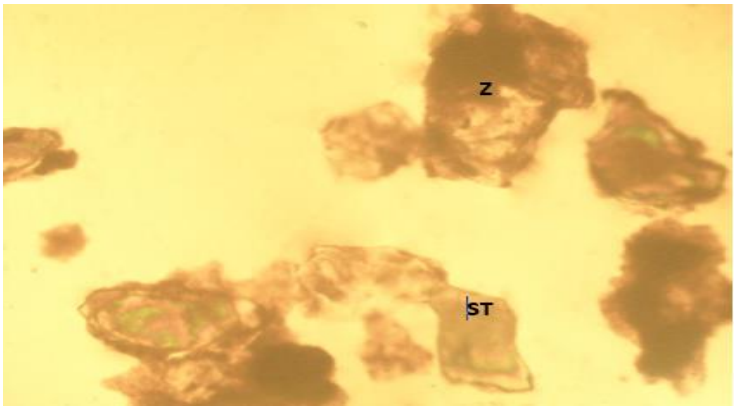

Figure 13. Photomicrograph of sample OGBR2C ppl1 in crossed polarized light

Z= ZIRCON, ST=STAUROLITE

5. Conclusion

Grain size distribution analysis indicates the River Ogun sediment samples are poorly sorted, the poor sorting of the sediment is due to the non-constant energy of wind and water during the time of deposition. This indicates that they are at proximal to distal distance from the source, are characteristic of fluvial to marginal marine settings (that is, high energy to low energy environment), have relatively high peaks are formed from a single sedimentary cycle. The heavy mineral analysis carried out on the sediment samples shows the sediment contained heavy minerals such as rutile, zircon, and staurolite mineral. Zircon and Staurolite have a high proportion compared to Rutile in the sediment. This study is significant in providing evidence of shallow marine conditions in the development of the River Ogun Sediments.

Future studies on the sedimentological and petrographic characteristics of the Ogun River sediments can be enhanced by increasing the sample size to include more locations and seasonal variations, providing a more comprehensive view of sediment characteristics over time. Utilizing advanced analytical methods such as SEM, XRD, and Laser Diffraction Particle Size Analysis will allow for more detailed insights into mineral composition and grain morphology. Further heavy mineral analysis, coupled with geochemical assessments (major, trace, and rare earth elements), will help refine the understanding of the river's provenance and depositional history.

Declarations

Source of Funding

This study did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests Statement

The author declares no competing financial, professional, or personal interests.

Consent for publication

The author declares that he consented to the publication of this study.

Authors' contributions

Author’s independent contribution.

Availability of data and material

Supplementary information is available from the author upon reasonable request.

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