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SIZE DISTRIBUTION AND HEAVY MINERAL PATTERN IN SOME EGBE STREAMS, SOUTHWESTERN NIGERIA.

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ABSTRACT

The Egbe-Isanlu schist belt has received scholarly attention from several researchers but there is no documented report on types and the distribution of heavy minerals in streams of the area. This study is intended to reveal the types of heavy minerals, the distribution and possible source rocks to guide prospectors in gems. The study area lies within latitude 08^{o} 03' and 08^{o} 16 ' and longitude 05^{o} 31' and 05^{o} 43' of the Southwestern Basement Complex terrain in Nigeria. Fifteen stream sediment samples were collected at appropriate points along river channels, air dried at room temperature, sieved and subjected to heavy mineral separation process using bromoform. Graphic mean, sorting, skewness and kurtosis were determined and heavy minerals identified under microscope. The graphic mean ranges between 0.67 (coarse sand) to 2.49 (fine sand), skewness between 0.75 and -0.10 and Kurtosis between 0.87 and 1.88. The calculated ZTR index ranges between 6.86% and 3.35.0%. The identified heavy minerals in the study area included tourmaline, epidote, rutile, zircon, kyanite, staurolite, garnet and zeolite. These minerals are modernly distributed across the sampled area and in some locations, they are relatively high in abundance. Some of the heavy minerals are angular to sub-angular in shape suggesting a short distance of travel from source. The graphic mean gives values that suggests a moderately to poorly sorted sediment and skewness indicated a platykurtic and leptokurtic nature for the sediments. Calculated ZTR index classified the sediments as immature to sub-mature indicating a short distance of travel suggesting that the sediments could have been derived within the catchment area. The presence of zircon, tourmaline and rutile suggests that the sediments might probably have its source from acid intrusive rocks and pegmatites.

KEYWORDS:- Bromofom ,Skewness, Kurtosis, Graphic Mean, ZTR Index, Symmetry, Immature

INTRODUCTION

The composition of heavy minerals in sediment is a reflection of the type of parent-rocks within a catchment area. Heavy minerals are good pathfinders of origin of sediments, revealing the provenance and transport history of sediments. The type, distribution, compositional variation and textural differences of heavy mineral in sediments defines the transport history as river load travels down slope through channels to basins of deposition and are dependable metals for provenance studies.

Streams and rivers are dynamic and sensitive systems that preserves the physical, chemical and biological character of its loads sediments. According to Jain et.al. (2005); Adeyemo et.al. (2008) and Aderogbin et.al (2020), stream sediment is an important tool for assessing and evaluating the quality of total environment. Typically, stream beds are reservoirs to uphill-loads from within a catchment area which can be used to infer the geology of a place. The heavy mineral distribution pattern especially in sand-sized terrigenous sediment was reported to be considerably influenced by

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sedimentary processes, post-depositional dissolution and provenance (Mange and Maurer, 1992). Heavy minerals are essentially part of a population of detrital and authigenic grains reflecting the basement geology of an area and supplies important information essential for the interpretation of an area

The present study was carried out within Longitude 05^o 31' and 05^o 43' and Latitude 08^o 03' and 08^o 16 ' of in Egbe area, Southwestern Basement Complex of Nigeria (Fig.1). The basement complex of Nigeria is located within the remobilized zone of the West African Basement. Various authors such as Jones and Hockey (1964); Pearce and Canny, (1973); Pearce and Gale, (1977), Turner, (1983); Elueze and (1981) classified the major rocks in the Nigerian basement complex terrain as Migmatite-Gneiss Complex , the schist belt , the Older Granites (the Pan African granitoid) with a wide range of composition and the charnockitic, gabbroic , dioritic and pegmatitic intrusions. Rahaman et.al (1988) further grouped the major rocks in the basement complex terrain as polycyclic migmatite–gness-quartzite complex, the meta-sedimentary and volcano-sedimentary rocks making up the schist belt, the chanokitic, gabbroic and dioritic rocks and the granitic rocks collectively referred to as Older Granites. Field study reveals the occurrence of quartz-mica-schist, small occurrences of quartzite, marble, pegmatite and silicate facies iron-formation exposures in some locations. The intrusion of meta-sedimentary rocks as inter-bedding with meta-igneous rocks like talc-schist and amphibolites intruding the granitoids, was previously reported by Olobaniyi, (2008).

Denser ultramafic and mafic igneous rocks and metamorphic rocks like amphibolites and granulites are favorable sources rocks for heavy minerals. Exposure of these rocks in some locations often serves as diagnostic marks that can provide evidence of the presence of heavy mineral conentration in the derived sediments of the area (Mange and Wright, (2007). Olobaniyi (2008) reported the occurrence of amphibolite of the area as small outcrops and residual hills conformably interbedded with suits of meta-volcano sedimentary rocks that reveals a mild-amphibolite facies assemblage of hormnblend, plagioclase and small amounts of quartz and biotite. According to Daly et.al. (1966), sedimentary to very low-grade metasedimentary rocks and felsic plutonic rocks like sandstone, granite and metasandstones have relatively low density (ð ≤ 2.70g/cm)^3 and are believed to provide only few heavy minerals in stream sediments.

Migmatite gneiss complex is characterized by a distinctive alternating bands of light-colored material (leucosome) and dark-colored **amphibole and biotite rich minerals (melanosome)**. The schist consists of fine-grained clastics, politic-schists, phyllites, banded iron-formations, marble and amphibolites considered to be of the Upper Proterozoic assemblages

In this study, attempts are made at identifying heavy minerals present in the sampled streams, determine the provenance and transport history of the sediments of the area

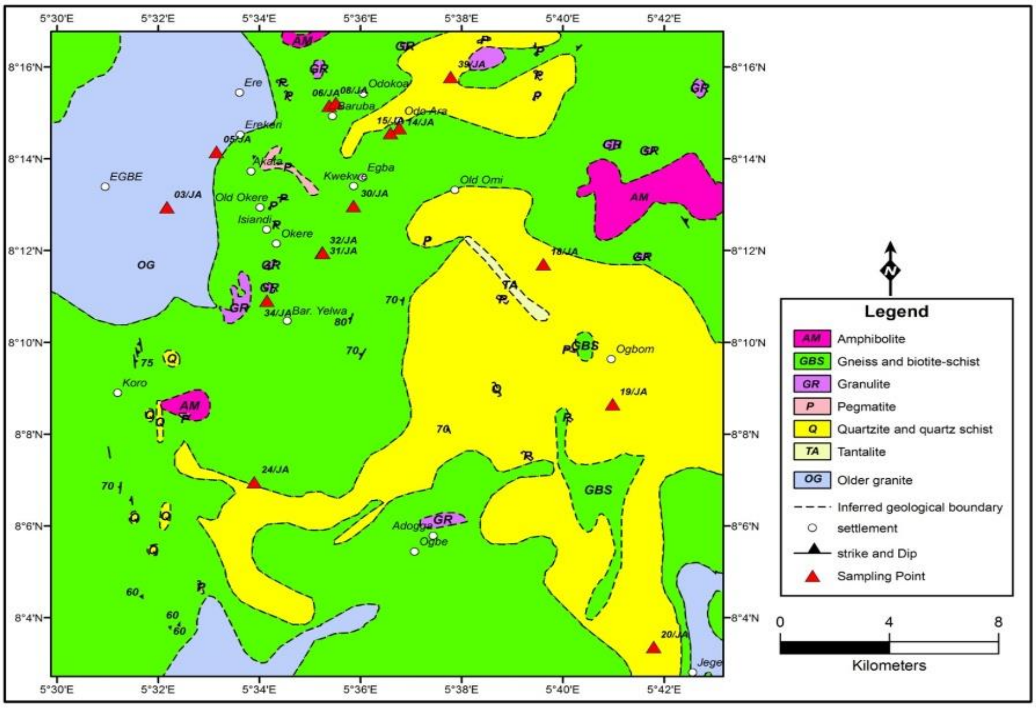


Fig.1: Geology Map of showing the Basement Complex within the Study Area

MATERIALS AND METHODOLOGY

Fifteen samples were collected at suitable points along river channels and air dried at room temperature. 200gram of each sample ware weighed and washed inside beaker with distilled water, placed in containers and transferred into a convection oven for drying. The samples were dried for few hours at temperature slightly below 100^{o}C Thereafter, 100 gram of each of the samples were sieved using mechanical sieve -shaker and sets of sieves of diameters 2.36 mm, 1.18 mm, 0.850 mm, 0.425 mm, 0.300 mm, 0.212 mm, 0.150 mm and pan. The sieve shaker was operated for fifteen minutes and weight retained on each sieve weighed and recorded.

Minerals having specific gravity greater than 2.85g/cm^3 sinks in bromoform and others float. The bromoform was poured into the upper funnel with second clips. The bromoform containing the samples ware left for fifteen minutes when the heavy minerals might have completely settled in the beaker. The first clip was locked while the second one was left open in order to allow the separated heavy minerals into the filter paper inside the second funnel. Acetone was run through the first and second funnel so as to wash and clean off the bromoform. Canada balsam was dropped on glass slides, heated plate and the separated heavy minerals carefully sprinkled on the slides. This was allowed to cook as recommended and the slides were properly labeled. The slides containing the heavy minerals were studied under petrographic microscope in the laboratory.

RESULTS AND DISCUSSION

The grain size distribution results for sediments from the study is presented in table 1 below. Value of the graphic mean which defines the average size of all the grains present in the sediment ranges between -0.4 (very coarse sand) to 3.3 (fine sand) suggesting that the sediment may have come from a low energy regime or perhaps due to morphological maturity of source rock. The uniformity of the grain size is measured by the sorting and it is an indication of the hydrodynamic condition, rate of violence and degree of turbulence operating in the transport medium during transportation. A wide values between 0.1 and 1.09 was recorded and this indicates a moderately to poorly and extremely poorly sorted sediment. The skewness from strongly-fine nearly symmetrical and the kurtosis showed values ranging from platykurtic to leptokurtic.

Table1: Grain Size Analysis of Sediments from Study Area

Location	Mean	Sorting	Skewness	Kutosis	Interpretation		
L1	0.5	1.0	0.7	0.6	Moderately well sorted	Fine skwed	Very platy kurtic
L2	-0.4	0.6	0.02	0.9	Extremely poorly sorted	Strongly fine skewed	Platy kurtic
L3	0.7	0.7	0.3	0.7	Extremely poorly sorted	fine skewed	Platy kurtic
L4	-0.8	0.9	-4.3	1.2	Extremely poorly sorted	Strongly fine skewed	Leptokurtic
L5	0.3	0.8	0.03	0.9	Extremely poorly sorted	Nearly symmetrical	Platy kurtic
L6	1.0	0.9	-0.3	1.1	Extremely poorly sorted	Coarse skewed	Meso kurtic
L7	0.6	1.0	0.3	1.0	Moderately well sorted	Strongly fine skewed	Meso kurtic
L8	0.3	0.9	0.5	1.0	Extremely poorly sorted	Fine skewed	Meso kurtic
L9	-0.2	0.6	0.4	0.04	Extremely poorly sorted	Fine skewed	Very Platy kurtic
L10	1.1	0.1	-0.8	0.2	Extremely poorly sorted	Nearly symmetrical	Very Platy kurtic
L11	3.3	0.8	0.5	0.7	Extremely poorly sorted	Nearly symmetrical	Platy kurtic
L12	0.9	1.09	-0.02	1.05	poorly sorted	Coarse skewed	Meso kurtic
L13	1.0	0.6	0.6	0.9	Extremely poorly sorted	Fine skewed	Platy kurtic
L14	0.8	1.2	0.6	1.1	poorly sorted	Fine skewed	Leptokurtic
L15	0.9	-0.8	0.02	0.8	Moderately sorted	Strongly fine skewed	Platy kurtic

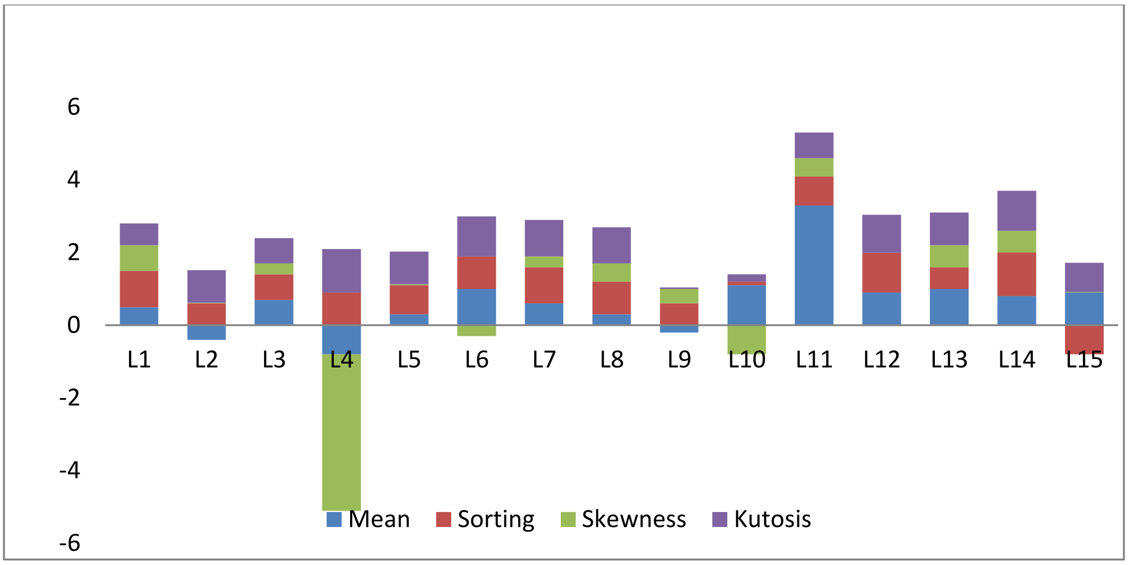


Fig. 2: Graphical representation of grain size analysis results

Heavy minerals observed under petrological microscope is shown in micrographs of figs 5 to 8 below. These minerals are tourmaline, epidote, rutile, zircon., kyanite, staurolite, garnet and zeolite and the spread across the study area is represented in fig. 2 and table 2. From the bar chart in fig 2, tourmaline, rutile, zircon and staurolite minerals are moderately distributed in the entire area. Locations 13 and 15 around Odo Ara area have high concentration of tourmaline, rutile, and zircon. In Location 7 and 10, around Ogga and Ogbe area, staurolite occurrence is significant. However, epidote, kyanite, garnet and zeolite are sparsely distributed across the entire field of the study. Rutile, tourmaline and staurolite are diagnostic metamorphic minerals (Folk, 1974) and their moderate distribution across the study area suggests a basement environment and a mix-source of igneous and metamorphic rocks.

Table 2: The distribution of Heavy Mineral in streams around Egbe region including individual mineral percentage abundance.

	Heavy minerals								
	Tourmaline	Epidote	Rutile	Zircon	Kyanite	Staurolite	Garnet	Zeosite	sum
L1	8	3	10	15	2	6	5	1	50
L2	7	1	9	7	2	4	2	2	34
L3	10	2	10	9	1	5	3	2	42
L4	16	3	12	10	2	7	-	6	56
L5	14	-	11	13	1	7	2	-	48
L6	9	4	12	13	-	5	5	-	48
L7	6	5	6	-	4	8	-	-	29
L8	9	4	12	17	3	4	2	1	52
L9	7	5	7	8	-	4	3	2	36
L10	6	-	5	9	2	8	-	-	30
L11	10	5	14	15	-	5	3	-	52
L12	7	6	10	12	2	4	3	-	44
L13	18	-	10	15	1	2	1	-	47
L14	5	7	12	11	1	6	-	-	42
L15	9	2	19	5	1	10	5	-	51
sum	141	47	159	159	22	85	34	14	661
%	21.33	7.11	24.05	24.05	3.32	12.86	5.14	2.12	99.98

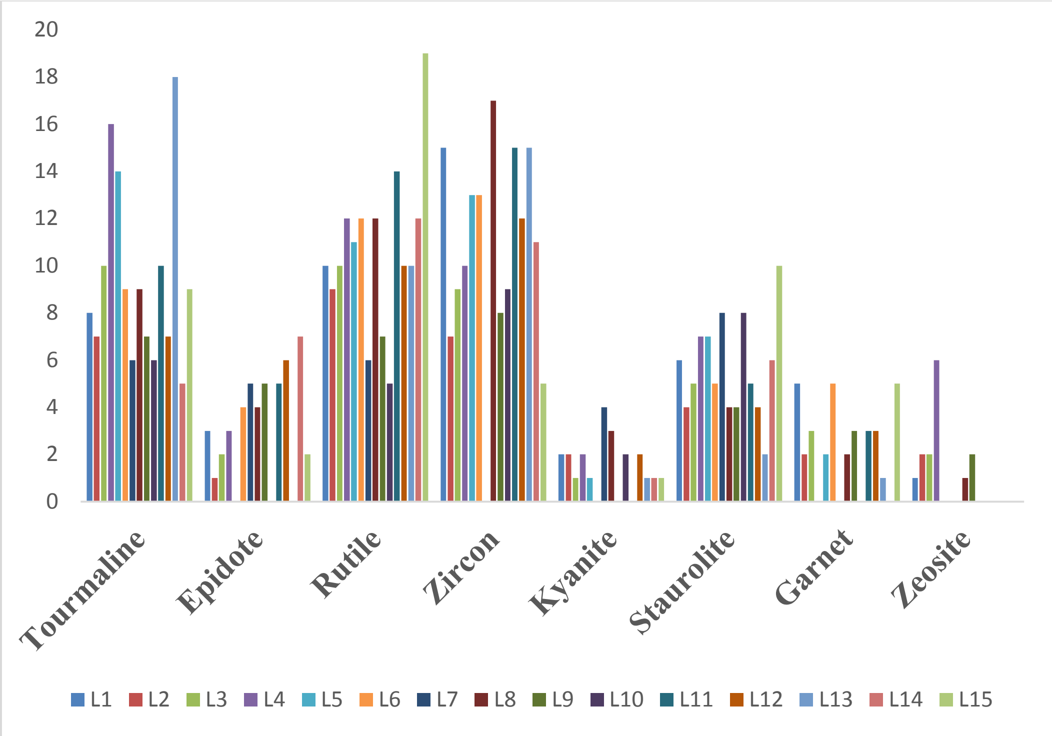


Fig 3: Graphical representation of the spread of identified Heavy Metals streams of the study area

The relative abundance and spread of the heavy minerals in representative sediment samples of Egbe streams (Fig.3) shows that Rutile (24.05%) and Zircon (24.05%) are relatively abundant in most samples. Rutile is an accessory mineral commonly found in high temperature and high pressure metamorphic and igneous rock terrains. It is the most common and stable form of **titanium dioxide** (TiO_2) and an important raw material in paint and optical equipment manufacturing. Zircon (ZrSiO4) **is a source of the metal zirconium** occurring as accessory mineral in igneous, metamorphic rocks and as detrital grains in sedimentary rocks. It is a raw material in ceramic industry (Nielsen, Ralph (2000), refractories, foundry casting and as **zirconia** and zirconium chemicals.

Tourmaline (21.33%) is next in abundance in the study area. **It occurs as accessory mineral in igneous and metamorphic rocks present in different colors. Some varieties of tourmaline are gemstone material. Staurolite (**12.86%**) is the third abundant mineral in the study area that occur as prismatic red, black to brown opaque mineral with a complex chemical formular ((**Fe, Mg, Zn)$_2$ Al$_9$ (Si, Al)$_4$ O$_{22}$**)** (OH)$_2$. It is an index mineral used in estimating the temperature, depth and pressure of rock that undergoes metamorphism. **Staurolite is a metamorphic mineral of intermediate to high-grade occurring with garnet, micas and kyanite. In the study area, garnet (5.14%), kyanite (3.32%) and Zeolite (2.12%) are low in abundance.**

The spatial distributions and relative abundances of heavy minerals in the study area show that tourmaline, rutile, zircon and staurolite are widely distributed and occur in all the locations.

Table 3: Table of ZTR Index of Sediments from Study Area

Location	Zircon	Tourmaline	Rutile	ZTR Index (%)
L1	15	8	10	5.80
L2	7	7	9	4.05
L3	9	10	10	5.11
L4	10	16	12	6.69
L5	13	14	11	6.69
L6	13	9	12	5.98
L7	-	6	6	3.35
L8	17	9	12	6.69
L9	8	7	7	3.87
L10	9	6	5	3.52
L11	15	10	14	6.86
L12	12	7	10	5.11
L13	15	18	10	7.57
L14	11	5	12	4.92
L15	5	9	19	5.80

The ZTR index (table 3), shows the degree of modification or maturity of the entire heavy mineral assemblage in the sediments within the study area. In a way, weathering index tells how weathered a sedimentary rock is. Zircon, tourmaline and rutile (ZTR) are resistant to weathering and have specific gravity within the recommended 2.8g/cm^3. They are responsive to environment of formation and stable during digenetic and metamorphic processes. The ZTR index for sediments from study area indicates that the sediments are immature to sub-mature, derived probably within the catchment area.

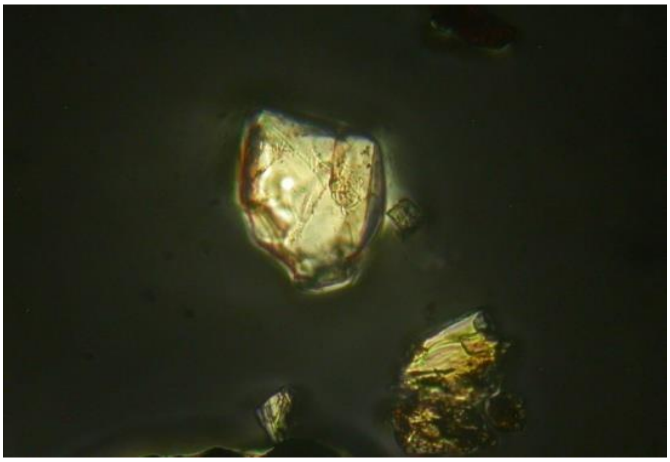


Fig.4: Garnet under cross nicol (×100)

Garnet (Plate 4) has a high relief, showing isotropic and opaque character under cross polar. **The** euhedral to subhedral crystal of garnet and high relief ware seen under the microscope **and this is diagnostic of garnet with the deep red to brownish red color of an** eight-sided cross sectional mineral

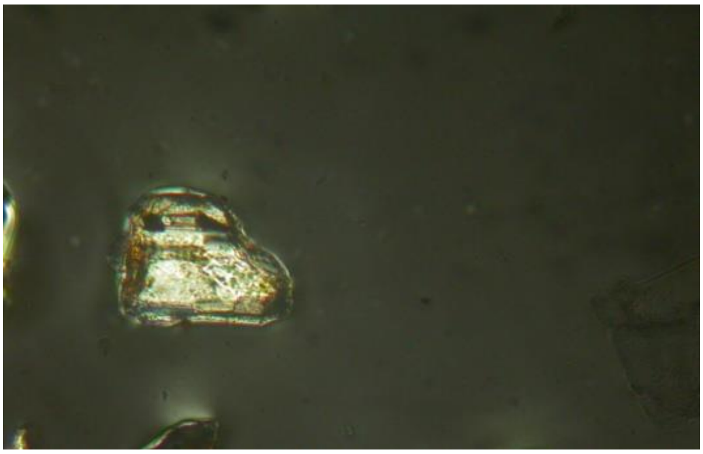
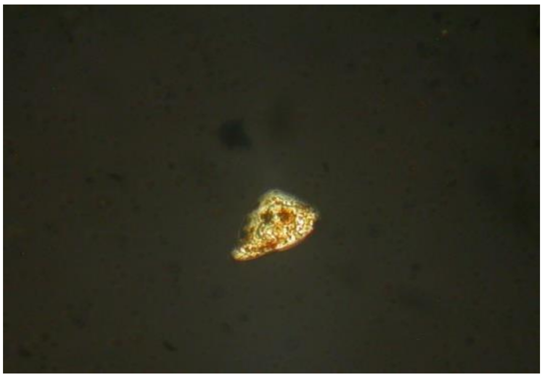


Fig.5: Kyanite under cross nicol (×100)

Kyanite is typically a blue aluminosilicate mineral occurring in aluminum-rich metamorphic pegmatites and sedimentary rock. Kyanite is colorless and dark under the microscope with a high positive relief (Plate 5). **Kyanite** displays two prominent, high angle parallel cleavages which occurrs perpendicular to the length of the crystal blades. Streak is white. Luster is vitreous. **It is a high pressure polymorph of andalusite and sillimanite, and the presence of kyanite in metamorphic rocks generally indicates metamorphism deep in the Earth's crust.**



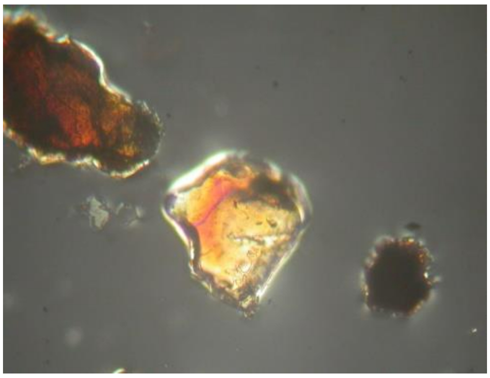
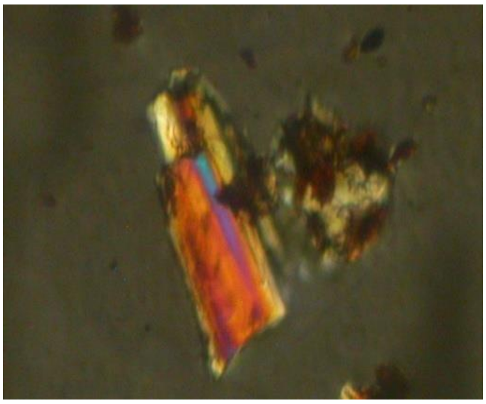


Fig 6: -Staurolite under cross nicol (×100)

Crystals of staurolite are usually prismatic and often twinned. Staurolite twinning varies from a 60° X-shaped twins to a **90° cruciform penetration twins and the cross twinning of staurolite crystals under microscope is a diagnostic future.**Staurolite color ranges from reddish brown to blackish brown and rarely does it occur as blue. It is mildly pleochroic from colorless to pale to golden yellow and transparent to opaque under the microscope. It is an index mineral that has experienced intermediate to high-grade metamorphism of aluminum-bearing parent sediments.



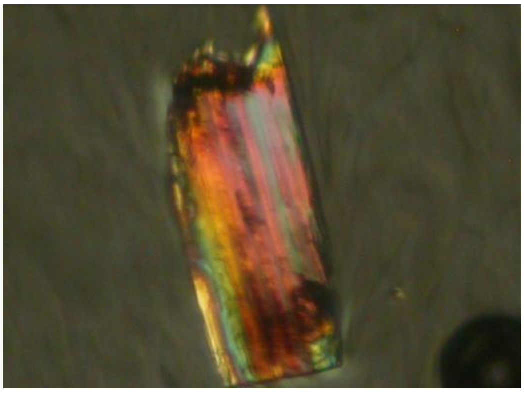


Plate 7: - Tourmaline under cross nicol (×100)

Tourmaline has a moderately positive **relief forming** euhedral, stubby columnar to acicular crystals with rounded, triangular or crudely hexagonal cross section (Plate 7). The mineral is intently **pleochroic with none cle**avage but irregular fractures. Tourmaline is anisotropic with zero degree extension angle and parallel straight in longitudial sections which remains dark on rotation.

Plate 8: - Zircon under cross nicol (×100)

In thin section, Zircon may be cloudy, showing concentric zoning or patchy colour with weak pleochroism in coloured varieties. Zircon crystals occur in other minerals showing very high relief and high-order interference colors (Plate 8**). It shows a v**ery high positive relief and a euhedral to subhedral tetragonal crystals with pyramidal terminations. Usually, zircon is colorless to pale brown, pale yellow, or gray. The p**leochroism is a**bsent to weak and none **cleavage.**

CONCLUSION

The sediments from rivers in the study area are texturally immature clastic sediments, characterized by rich and varied assemblages of heavy minerals of which tourmaline, epidote, rutile, zircon., kyanite, staurolite, garnet and zeolite are predominant.

The spread of these metals indicated that tourmaline, rutile, zircon and staurolite minerals are moderately distributed with some locations showing unusually high presence of these minerals and epidote, kyanite, garnet and zeolite sparsely distributed. The high occurrence of these minerals towards the north and southern axis of the study area is a guide for prospecting for these minerals in the area.

The ZTR index of the sediments are an indication that the sediments are immature to sub mature which was derived probably within the catchment area. The nature of the minerals gives an indication that they have not travelled far distance from source.

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