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DETERMINATION OF ORIGIN AND GRANULOMETRIC ANALYSIS OF RIVER CHANNEL SEDIMENTS OF OSI, SOUTHWESTERN NIGERIA

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ABSTRACT
Osi is located within the south-western part of the Nigerian Basement Complex and plays a host to unconsolidated deposits and major examples of Precambrian – Paleozoic crystalline rocks in the region. Detailed geological mapping revealed the area to comprise essentially of migmatite – banded gneiss complex and diorites and minor rock types that include pegmatite and quartz veins. Superficial stream sediments occur abundantly and proximally along channels in the vicinity. These river channels host considerable amount of loose deposits that are useful for sedimentological and provenance study. While efforts have been committed to regional mapping, petrography and geochemistry of rocks in the region, little attention was paid to the associated stream sediments. This study adopted geological mapping of the crystalline rocks and sieve analysis of the stream sediments, as well as the use of XRF and inductively coupled plasma Mass spectrometry (ICP – MS) to establish some relationship between the basement geology and the surrounding deposits in the area. Migmatites are abundant in the south-west and parts of the north-west, while granite gneisses with isolated occurrence of diorite are confined to the north-east of the study area. Granulometry of the sediments revealed a predominantly medium – coarse grained, poorlysorted leptokurtic sands, indicating products of in-situ weathering of host rocks. Geochemical analysis supports a strong correlation between the rocks and the sediments. The study is applicable to enhanced understanding of grain-size distribution and in regional mapping and geochemical method of exploration.

Keywords: Basement complex, migmatite – gneiss complex, stream sediments, grain-size analysis, elemental abundance, south-western Nigeria.

INTRODUCTION

Osi, which covers approximately 65.54km^2 in the south-western Nigeria, is part of Nigerian Basement complex which belongs to the West-African Precambrian to Early Paleozoic orogeny, comprises of Precambrian crystalline rocks with associated infolded Schist belts. The South-western Nigeria (Figure 1) that hosts the study area (Osi) is generally represented by series of older metasediments and gneisses that are known to be of Precambrian to Lower Paleozoic age (Oyawoye, 1972). Abundant literatures (Kennedy, 1964; Oyawoye, 1972; Rahaman, 1976; Anifowose, 2007; Annor, 1986 and Ajibade, 1987) are available on the geology and geochemistry of the Southwestern Nigerian Basement complex. Oyawoye (1972) classification typified the rocks in this region as older granites, migmatitic complex, metasedimentary series of schists, amphibolites, marble and calc-silicates, as well as miscellaneous rocks that include charnockite, diorite, gabbro and metagabbro, potassicsyenites and doleritic rocks. A general trend of north-east and south-west has been determined for rocks in thearea. Foliations in the region are essentially tectonic in origin with clear vestiges of pre-existing structures being replaced by deformational structures (Odeyemi et al. 1999).

Most of the studies carried out in the area were focused on outcrops, petrography, geochemistry and structural analysis of the rocks with less regard for the linkage between the crystalline outcrops and the surrounding superficial deposits. Therefore this study attempts a detailed geological mapping and grain-size analysis of the associated river channel deposits in the area.

Geologic setting

The Basement complex of Nigeria, which lies between 6°N and 12°N latitudes and 4°E and 12ºE longitudes, is of Precambrian to Early Paleozoic orogenic episodes. It has suffered the supracrustal plutonism. It extends westwards and into the Dahomey super Basin that includes the Togo and Ghana regions. It extends further Northwards into Niger Republic, eastwards into the Cameroon, and is overlain by a Mesozoic – Recent rocks of the coastal basins of Dahomey and Niger Republic (Grant, 1969; Ajibade and Wright, 1989).

The Nigerian Basement complex is classified broadly into three; the gneiss-migmatite complex, the metasedimetary schist belt and the older granite.

The gneiss-migmatite complex comprises rocks of Archean (3000Ma) and Earliest Proterozoic (2000Ma) ages (Oversby, 1975; Dada et al. 1995) and forms the base upon which the metasedimentary schist belt is deposited.

The region suffered series of tectonic events that transformed them into various lithological groups (Rahman, 1988).
Superficial sediments refer to the loosely consolidated deposits that occur proximal to the base of the Basement complex rocks. They appear as by-products of denudation of older rocks. They are generally gravely, sandy, muddy and lateritic materials occurring mainly in major valleys. These sediments are pre-dominated by quartz and feldspathic minerals. Most of the rocks in the area have been affected by deformational tectonics, with associated quartzose and feldspathic intrusive rocks with varying degree of jointing (Anifowose and Borode, 2007).

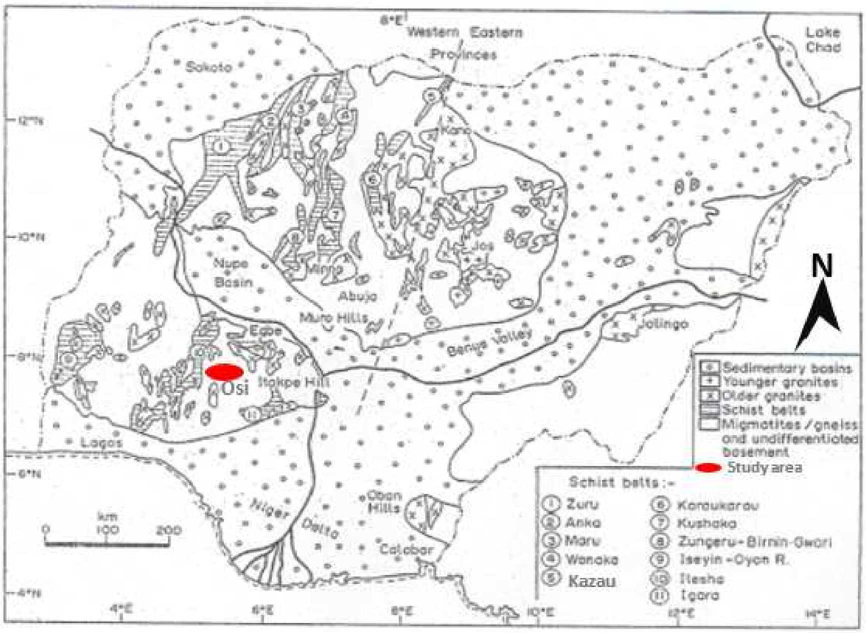


Figure 1. Generalized geological map of Nigeria showing the Basement Complex rocks provinces and the study location, Osi (modified after Rahaman, 1988)

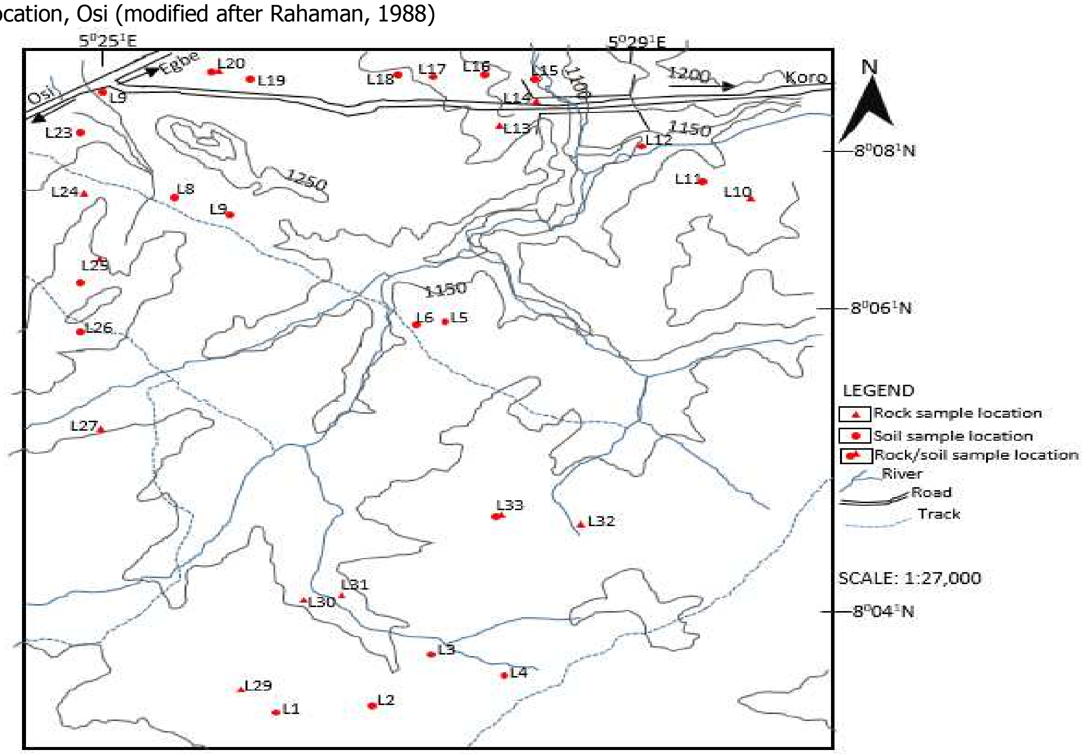


Figure 2.Topographical map of part of Osi SE (Sheet 224, Southwestern Nigeria) showingsample locations

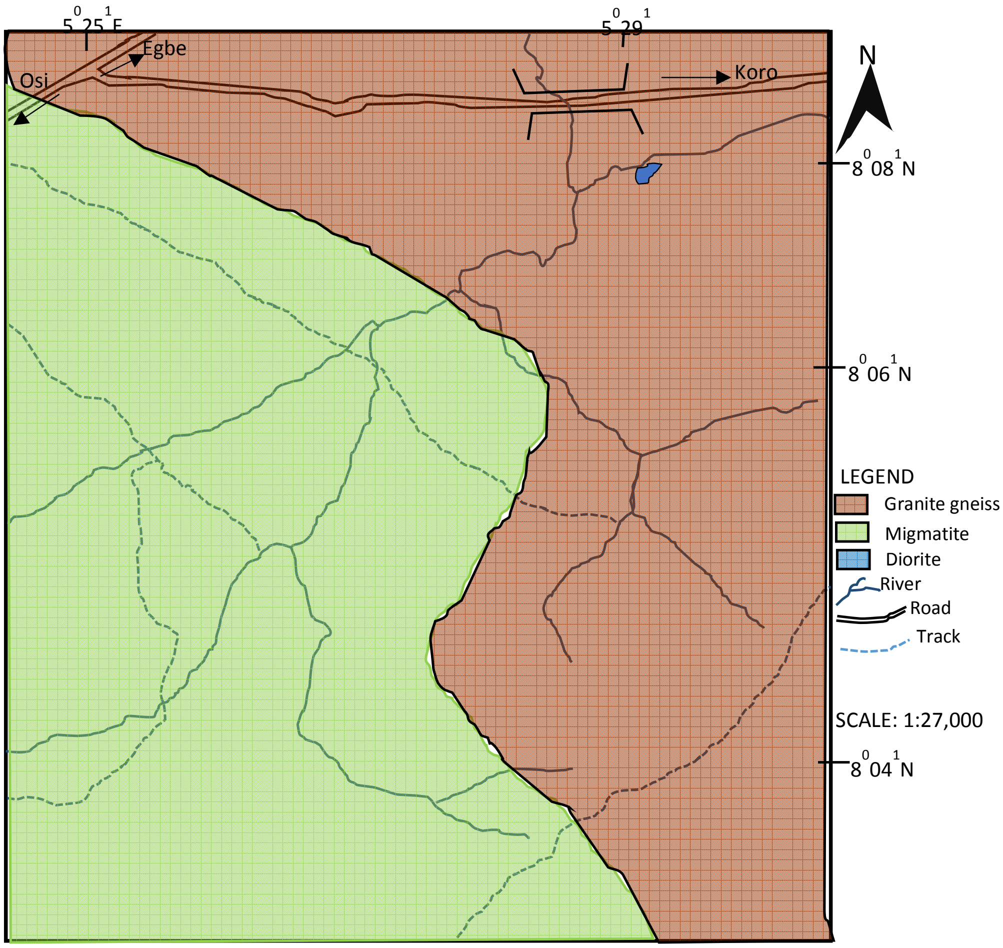


Figure 3. Geological map of part of Osi (Sheet 224, Southwestern Nigeria)

MATERIAL AND METHODS

This study employed field mapping, sampling, petrography and granulometry to establish the geology, geochemical properties as well as grain-size distribution of the channel sediments rocks, and the relationship between the basement rocks and the superficial deposits. Outcrop mapping and descriptions and collection of representative samples (Figure 2) from the exposed rocks was carried out in the area. Thin section slides of ten(10) rock samples were prepared and carefully studied under petrological microscope in order to establish the mineralogical compositions and fabrics of the rocks. While X-ray Fluorescence (XRF) spectrometry and inductively coupled Plasma Mass Spectrometry (ICP - MS) were used for quantitative elemental analysis, and grain-size analysis was performed on12 stream sediment samples (Figure 2) that were taken from the base of rock outcrops and from accessible stream channels in the area using set of sieve pans with the sieves arranged in order of increasing aperture size and the sample poured into them from the top (1mm sieve) and covered, then positioned in the vibrator and the machine was operated for 10minutes following Folk and Ward (1957) standard methods and procedures to determine the mean distribution, sorting, skewness and kurtosis of the stream sediments.

RESULTS AND DISCUSSION

Field mapping showed that Osi (Figure 3) is located within latitudes 8°04'N and 8°09'N and longitudes 5°25'E and 5°29'E, and is made up of migmatites and granite gneisses with some miscellaneous rocks and significant superficial deposits. River channels occur randomly distributed especially close to the bases of the crystalline host rocks.

The petrography of the Basement complex rocks is shown in Figure 4. Migmatite, banded gneiss, granite and an isolated diorite (Figure 3) ridge are the predominant rock types. The main components are quartz, Feldspar (Microcline and Plagioclase), Mica, Hornblende and some opaque minerals. From the analysis, quartz represents the predominant mineral component of the rocks occurring with the highest percentage in granite (>40%) and lowest in the diorite where it averages 10% in aggregate rock composition.

Microcline are most dominant in the migmatites and granite gneisses ranging from 25% – 40%; they likely indicate granite origin (Imaseun et al. 2013). This sort of mineral assemblage indicates emplacement in continental environment (Ayodele, 2015).

The stream sediments analysed are characteristically brown to dark-brown in colour and are micaceous. They contain predominantly quartz and varying degree of feldspar, and fragments. The results of the sieve analysis of the stream sediments (Table 1) was used to create the histogram plots (Figure 5). Most of the samples have their modal classes between grain sizes 0.075mm to 0.25mm and between 0.25mm to 0.5mm which correlate with medium – coarse grained sands. From the table 2 and histogram plots,a graphic mean of range of -0.37 – 1.40 (Table 2) interpreted using Wentworth (1922) scale indicated medium sand to very coarse sediments. The grains generally range between very poorly sorted to poorly sorted, and mostly very leptokurtic to leptokurtic with a few showing platy kurtosis (granulometric interpretation is summarised in Table 3).About 35% of the grains are nearly symmetrically skewed, 25% negatively skewed, another 35% are positively skewed while 5% are strongly coarse skewed. This skewness indicates that sediments are products of in-situ weathering that were deposited proximal to the source. Bivariate plots of skewness and sorting (figure 6) supported a fluvial origin of the sediments, with the predominantly poor sorting and leptokurtic characteristics indicating evidence of river transport system that experienced episodes of fluctuating high and low energies (Friedman, 1967).

XRF results ICP-MS results (Tables 4), is a quantitative technique that assists in subdivision of the elements as major, minor and trace elements and it agrees with Goldschmidts (1954) division of elemental compositions of rocks into major elements (those that have their elemental composition greater than their presence in the crust) and minor elements (referring those elements whose sample composition is greater than their presence in the crust). The major elements in the analysed samples include Fe, Ca, Mg, Al, Ti, Na, K and S; these are present in concentrations >1000 ppm i.e. >1%. Also noticed is relatively elevated level of Ba and Rb. The method is useful as guide to regional mapping and applicable to Basement complex geochemistry (Ayodele, 2015) and in geochemical prospecting of minerals like gold, platinum, etc. (Rose, 1974).

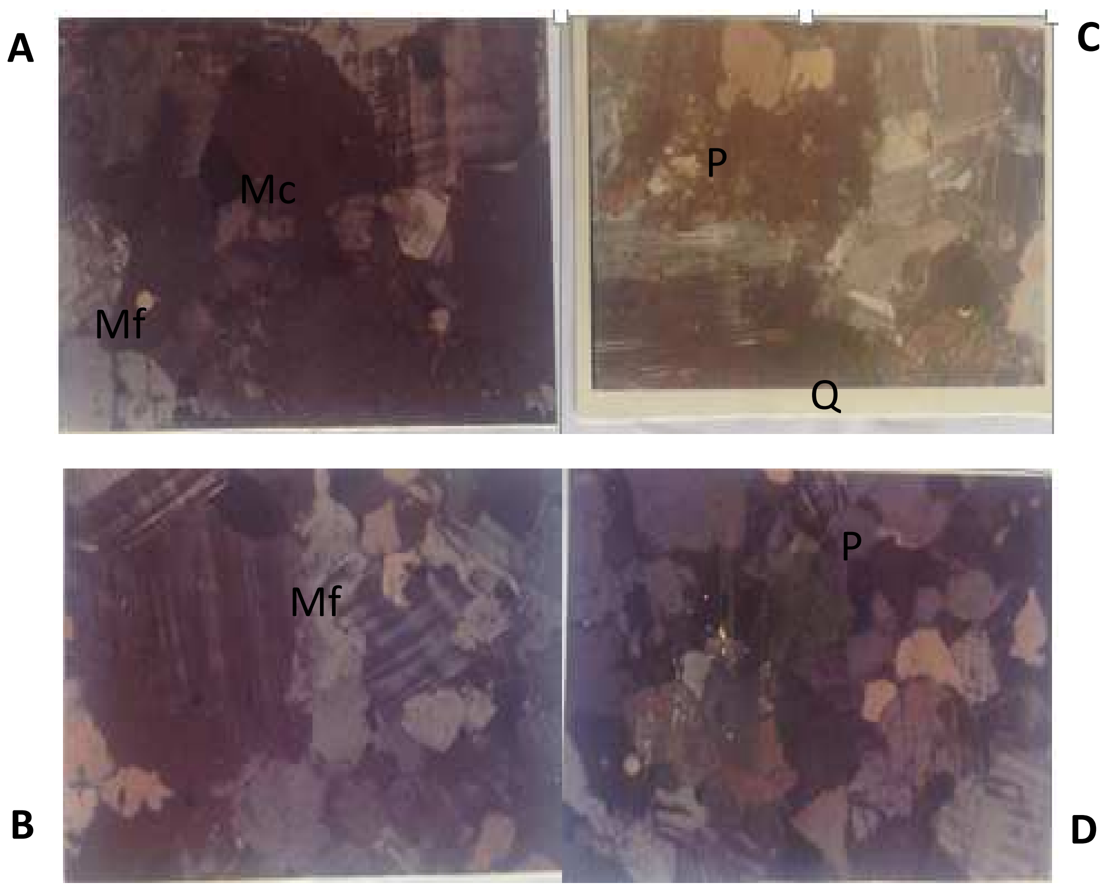


Figure 4. Petrography of some of the rocks in the study area (magnification x40): A and B represent migmatite-gneiss rocks; C = Diorite; D = Granite; Mc = muscovite; Mf = Microcline feldspar; P = Plagioclase; Q = Quartz

Table 1. Results of sieve analysis conducted on 12 stream sediment samples collected from the area.

Sample/Retained Weight (%)	1mm	0.5mm	0.25mm	0.075mm	<0.075mm	Total(%)
SS 10	14.8	26.5	33	22.5	3	99.8
SS 13	9	24	39	26	1	99
SS 14	24	57	17	1	0.5	99.5
SS 20	35	25	21	15.5	3	99.5
SS 24	11.5	28	34	22	4	99.5
SS 25	20.5	32.3	24	18	5	99.8
SS 27	34.7	24	22	15	4.2	99.9
SS 29	8.5	22	32	30	6	98.5
SS 30	23	28.5	27.5	18	2.5	99.5
SS 31	31	23	25	19	1	99
SS 32	37	19	15.7	23	5	99.7
SS 33	24	14.3	25	29	7.5	99.8

Table 2. Calculated graphic properties of the stream sedimentswith the estimated Phi values from cumulative frequency curves

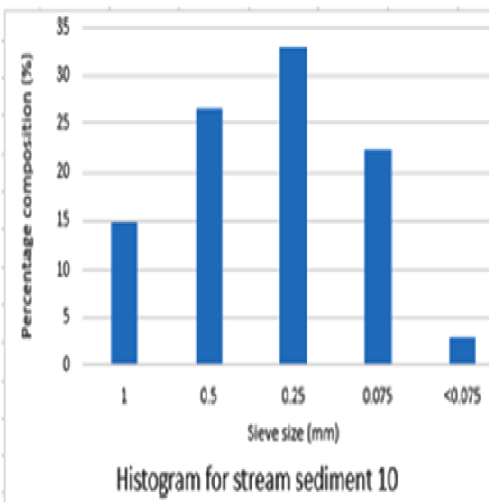
Sample	Mean	Sorting	Skewness	Kurtosis	Ø5	Ø16	Ø25	Ø50	Ø75	Ø84	Ø95
SS 10	1.12	1.26	-0.01	1.66	-1.5	0.1	0.55	0.9	1.95	2.35	3.05
SS 13	1.27	1.16	0.12	1.3	-1.2	0.4	0.6	1.1	1.75	2.3	3.3
SS 14	-0.37	1.33	-0.29	1.88	-2.5	-1.5	-0.85	0.25	0.7	1.15	1.85
SS 20	0.52	1.8	0.09	0.53	-2.3	-1.35	-0.8	0.3	1.85	2.6	3.05
SS 24	1.4	1.36	0.14	1.44	-1.25	0.25	0.7	1.15	2.05	2.8	3.5
SS 25	0.95	1.73	0.06	1.21	-2.05	-0.65	0.15	0.8	2.15	2.7	3.85
SS 27	0.45	1.94	-0.2	1.01	-2.55	-1.8	-0.8	0.85	1.7	2.3	3.6
SS 29	1.57	1.51	0.27	1.16	-1.2	0.35	0.8	1.15	2.65	3.2	4.05
SS 30	1.03	1.56	-0.49	1.24	-2.15	-0.8	0.5	1.8	1.85	2.1	3.3
SS 31	0.65	1.84	-0.01	1.15	-2.6	-1.15	-0.75	0.6	1.5	2.35	3.74
SS 32	0.58	2.04	0.04	0.17	-2.45	-1.65	-0.95	0.5	2.5	2.9	3.55
SS 33	0.92	1.8	-0.14	0.8	-2.2	-1	-0.9	1.1	2.1	2.65	3.68

Table 3. ICP – MS analysis of some samples digested with acids (2 L35 PS = pegmatite; 2 L29 SS = soil sample; 2 L 11M = Muscovite; 2 L 21F = Feldspar

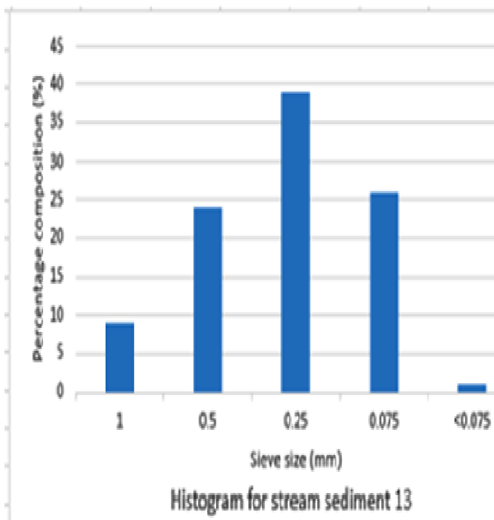
Element	Conc.(ppm) of 2 L35 PS	Conc.(ppm) of 2 L29 SS	Conc.(ppm) of 2 L11 M	Conc.(ppm) of 2 L21 F
Y	14.9	7.8	0.7	2
Ce	59.54	69.69	3.64	0.59
Pr	4.9	6.6	0.3	0.1
Nd	17.6	23.9	1.2	0.3
Sm	3.8	5.2	0.3	0.1
Eu	0.7	0.5	<0.1	0.2
Gd	2.5	3.2	0.3	0.1
Tb	0.4	0.4	0.08	0.09
Dy	2.5	1.9	0.2	0.3
Ho	0.5	0.3	0.1	<0.1
Er	2.2	0.8	0.1	0.5
Tm	0.3	0.1	0.09	0.08
Yb	2.7	0.8	0.1	0.5
Lu	0.4	0.1	0.09	0.1
Hf	3.14	2.33	0.64	0.09
Li	30.2	3.9	121	15.7
Rb	195.4	126.1	954.7	576.1
Ta	2	1.1	29.3	0.8
Nb	13.4	9.86	227.84	2.11
Cs	4.9	1.8	49.9	3.6
Ga	17.35	8.48	101	19.18
Ca	1.48	0.22	0.04	0.17
P	0.021	0.015	0.013	0.003
Mg	0.45	0.06	0.47	0.01
Fe	2.27	0.85	1.85	0.05
Ba	755	954	95	226
Ti	0.253	0.331	0.188	0.001
Al	5.84	4.32	18.39	8.86
Na	1.81	0.408	0.567	1.802
K	**2.59**	**3.68**	**9.71**	**11**

Table 4. Interpreted grain size characteristics of the analysed stream sediments and soil in the area

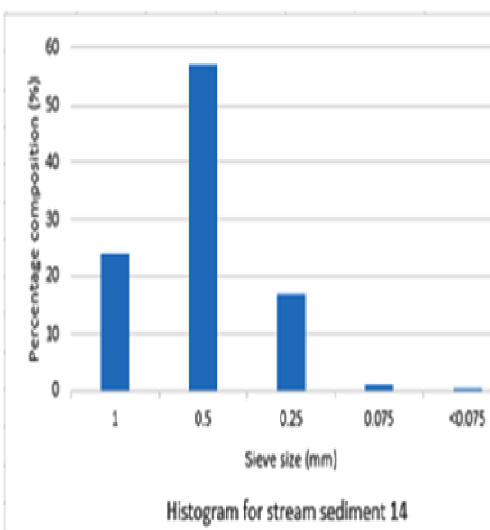
Sample	Graphic mean	Inclusive standard deviation	Inclusive skewness	Kurtosis
SS 10	Medium sand	Poorly sorted	Nearly symmetrical	Very leptokurtic
SS 13	Medium sand	Poorly sorted	Positively skewed	Very leptokurtic
SS 14	Very coarse sand	Poorly sorted	Negatively skewed	Very leptokurtic
SS 20	Coarse sand	Poorly sorted	Nearly symmetrical	Very platykurtic
SS 24	Medium sand	Poorly sorted	Positively skewed	Leptokurtic
SS 25	Coarse sand	Poorly sorted	Nearly symmetrical	Leptokurtic
SS 27	Coarse sand	Poorly sorted	Negatively skewed	Mesokurtic
SS 29	Medium sand	Poorly sorted	Positively skewed	Leptokurtic
SS 30	Medium sand	Poorly sorted	Strongly coarse skewed	Leptokurtic
SS 31	Corse sand	Poorly sorted	Nearly symmetrical	Leptokurtic
SS 32	Coarse sand	Poorly sorted	Very Positively	Platykurtic
SS 33	**Coarse sand**	**Poorly sorted**	**Negatively skewed**	**Platykurtic**



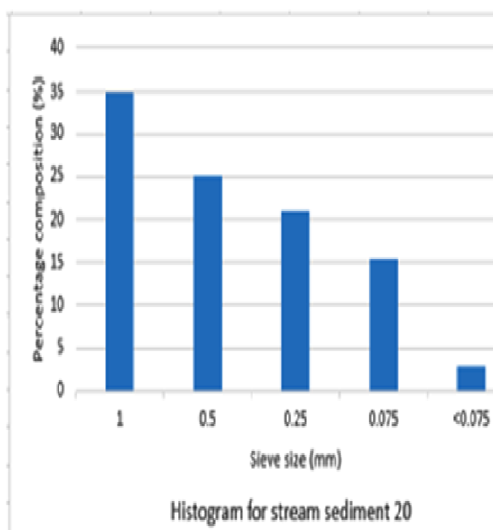
Histogram for stream sediment 10



Histogram for stream sediment 13



Histogram for stream sediment 14



Histogram for stream sediment 20

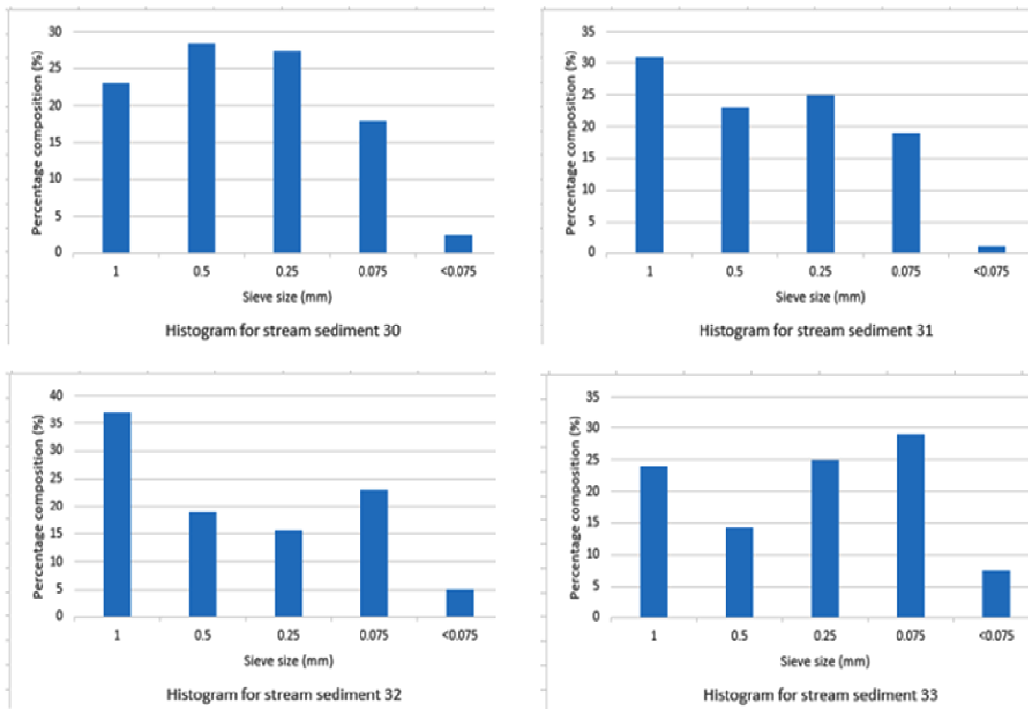


Figure 5. Histogram plots of the grain size analysis of the selected stream sediments in the area. The predominant grain sizes is 0.25 – 0.5 mm indicating coarse – very coarse grained deposits; the least common grain size is <0.075 – 0.075 mm.

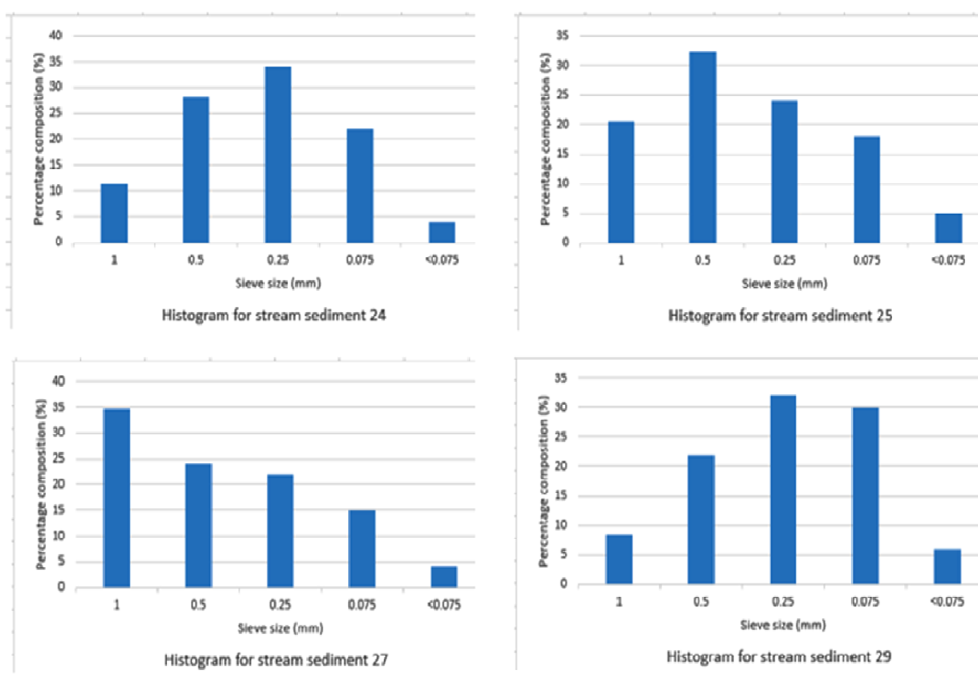


Figure 5 continued. Histogram plots of the grain size analysis of the selected stream sediments in the area. The predominant grain sizes is 0.25 – 0.5 mm indicating coarse – very coarse grained deposits; the least common grain size is <0.075 – 0.075 mm.

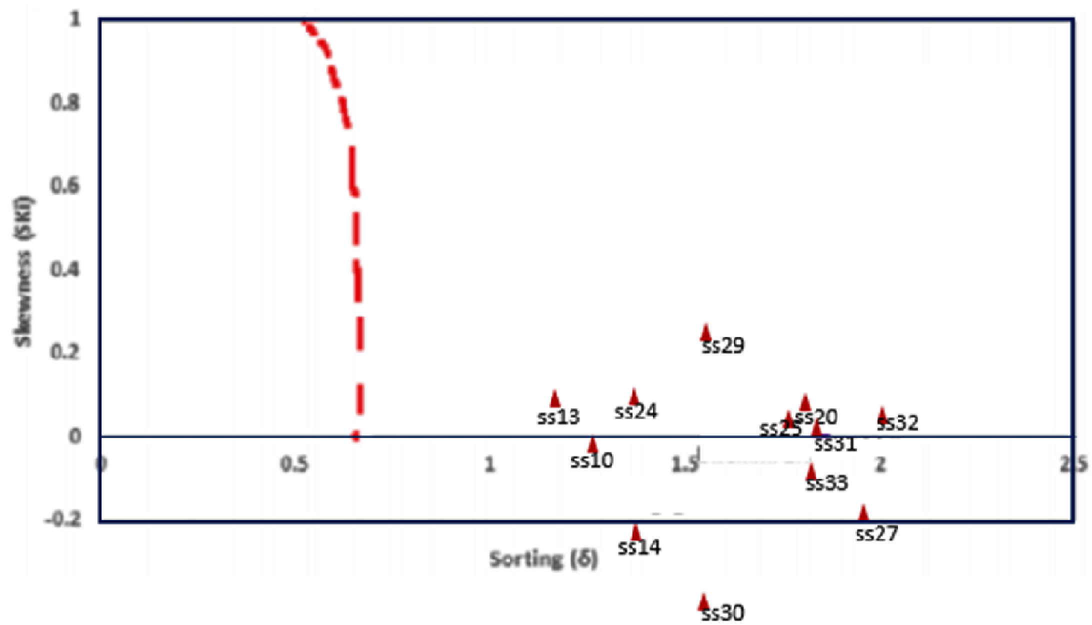


Figure 6. Bivariate plot of skewness and sorting indicated fluvially-sourced sediments; adapted from Friedman (1967). SS = stream sediment sample

CONCLUSION

Osi area is characterized by the predominance of migmatite-gneiss complex that exhibited continental characteristics, and by some occurrence of river channel deposits. Grain-size analysis of the stream sediments indicated coarse – very coarse sediments with very poorly to poorly sorted grains. This suggests sediments derivation from proximal source and as products of in-situ weathering of the parent crystalline rocks.

The XRF and ICP-MS analysis quantified the elemental abundance in the rocks and the sediments. Such approach is useful in regional mapping and in geochemical mineral exploration.

Authors' contribution

Mutari Lawal was the lead field geologist, digitized the maps and figures, carried out the grain-size analysis and sedimentological interpretation, report writer as well editor of the report.

Habib Adamu Ibrahim, Haruna Muhammed Grema, and KithaMbitsa all contributed meaningful insights on mineralogy and petrography of the study area, as well as some insight on the grain-size analysis.

Nura Abdulmumini Yelwa, Ibrahim Muhammed Abdullahi and Abdullahi Muhammad were responsible for editing and updating of the maps, figures and results.

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