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Full Length Research Paper

Geochemical drainage survey of Ikere and Environs, South western Nigeria using stream sediments

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Stream sediment geochemical survey was carried out around Ikere and its environs with the aim of assessing its mineral potentials. The method of study includes field examination of the underlying lithologic units in the study area, coupled with the collection of ten (10) stream sediments samples using grid controlled sampling method at a sampling density of one sample per 4 sqkm^2. The samples were later digested using the total acid digestion method and subsequently analyzed for its major and trace elements using Multi-Collector High Resolution Inductively Coupled Plasma Mass Spectrophotometry (MC-ICMPS) technique. The result of field examination revealed the prominence of three main lithologic units in the study area namely: porphyriticgranites, charnockites and medium grained-migmatites, with well-defined boundaries. The results of geochemical analysis indicated high concentration of silica and moderate concentration of alumina. SiO_2 has (48.87-92.25%) and Al_2O_3 (2.45-16.42%) respectively. The result of trace elements analyzed also revealed high concentration of Ba (186-1308 ppm), followed by Mn (1402 ppm), Ce (175 ppm) and Sr (313 ppm). The Petrogenetic character of the sediments as established on the Na_2O/Al_2O_3 vs K_2O/Al_2O_3 discriminant diagrams showed that the stream sediments are largely of igneous origin.

Key words: Ikere, stream sediments, rock units, anomalies, geochemical plots, statistics.

INTRODUCTION

Stream sediments originate from near the surface of exposed rocks of igneous, sedimentary and volcanic origin. Some of these are easily eroded, whereas others especially the crystalline and metamorphic rocks are affected by stream only when altered in surface layers. Additional sources of stream sediments are soils which inherited their minerals constituents (with some alterations) from bed rock of which in the tropics may consist completely or newly formed minerals (Irion, 1987). Most stream sediments in south western Nigeria are derived from the basement complex which covers about half of the land mass of the Nigerian landscape. The Nigeria basement complex forms a part of the Pan-African mobile belt and lies between the West African and Congo cratons and South of the Touareg shield. In stream sediments, a whole range of the known minerals can be found such as heavy minerals which are the most important group. Heavy minerals are known to occur in igneous, metamorphic and sedimentary rocks. These minerals are of high specific gravity and are economically valuable if they occur in sufficient large concentrations and in deposit of sufficiently large size (Joshua and Oyebanji, 2010). Studies have been made by numerous workers in the study of stream sediments to unravel its characteristics and importance. From the records of previous workers we are able to determine that stream sediment contain a wide range of minerals such as salt mineral, heavy minerals, clay mineral and also organic matters. Emmanuel et al. (2011) carried out geochemical investigation of the southern part of Ilesha with the aim of clarifying the potential source of mineralization in the area. Geologic mapping of the area revealed that the area is made up of different lithologies such as undifferentiated schists, gneisses and migmatites with pegmatites, schists and epidiorite complex, quartzite and quartz schist. Sixty-one soil samples were collected and analyzed for elements such as Pb, Fe, Ni, Cd, Cr, Cu, Zn and Mn, using multivariate analysis to obtain the

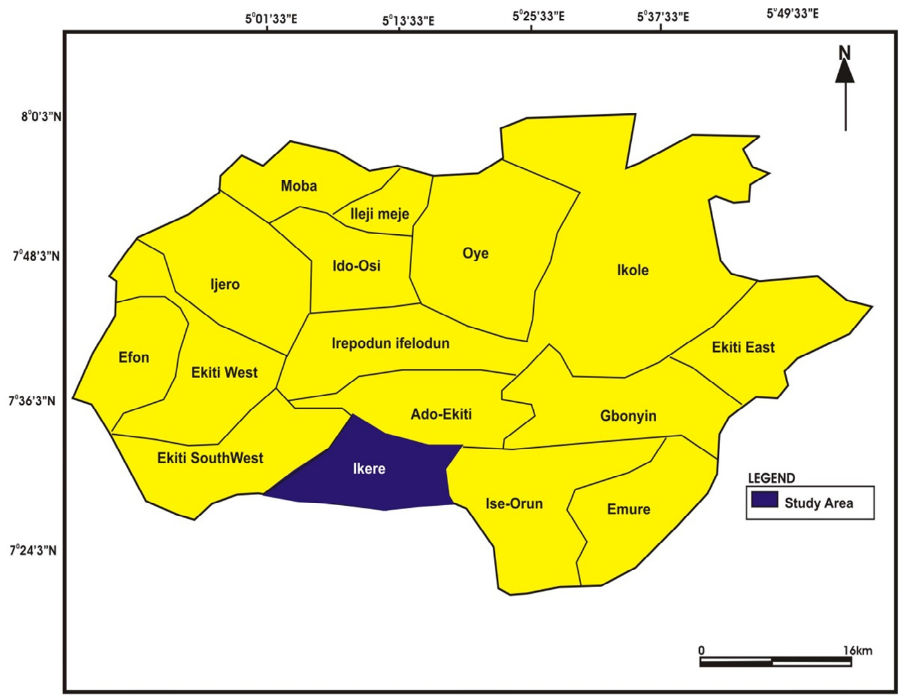

Figure 1. Map of Ekiti showing the study area.

coefficient of principal components. The elemental association ratio revealed high metallic concentrations which led to the mineralization trend in southern Ilesa. Okunlola and Okorojafor (2009) studied the geochemical and petrogenetic features of the schistose rocks of the Okemesi fold belt, and revealed that the meta-sedimentary assemblages which form the inner portion of the Okemesi antiform are continental post Archean supracrustals. Ajayi (1995) interpreted regional soil and active stream sediments by using moving average and trend surface technique from Ilesha gold field and concluded that the techniques are useful for interpreting geochemical data and applicable where anomalous/background contrasts are generally low. Ajayi (1981) also carried out statistical geochemical exploration in Ife/Ilesha of 176 stream sediment samples from an area of 1800 km^2 for copper, zinc, manganese, nickel and cobalt and found out that all the elements have density distribution closely approaching lognormal. The factor analysis for Cu-Co-Ni correlates spatially with areas underlain by amphibolite complex, thus reflecting the parent rock as the influencing factor. Awosika et al. (1982) conducted a research on the heavy minerals in the Nigerian river sediments and concluded that the textural properties of terrigenous sediments are almost entirely controlled by transportation and depositional environment while its mineralogical composition is a function of provenance. The occurrence and abundance of heavy minerals suits are influenced by various factors such as specific gravity and hardness of individual minerals. Some minerals such magnetite, tourmaline, Zircon, rutile and sphene can form authigenically in sediments. Also, in terms of structural architecture in rocks which creates pathways for mineralization, Anifowose et al. (2006) noted that joints ranging from minor to larger ones are found in all the rock types and generally lies in the NW-SW direction with minor variations in NWE-SSW and NE-SW directions. Boesse and Ocan (1992) reported that the southwestern basement complex of Nigeria has been affected by three phases of deformations mainly D_1, D_2 and D_3. The first phase 'D_1' produced tight to isoclinals folds while the second phase 'D_2' is characterized by more open folds a variable style and 'D_3' consists of large vertical NNE-SSW trending faults. Oluyide (1988) gave information that the primary structures in the basement complex have been completely obliterated tectonic deformation except in few places where they survived deformation (Okonkwo, 1992). However, this study attempts to assess the mineral potentials in the new and old drainage channels in Ikere-Ekiti and environs for possible mineralization.

Location, accessibility and human settlement

Ikere-Ekiti is located within Ikere local government area in the southern part of Ado-Ekiti, Ekiti State (Figure 1). It is located on latitudes 7° 30'N – 7° 35' N and longitudes 5° 10' E – 5° 15' E respectively covering a total area of 346.5 km^2. It is also situated between Ado-Ekiti (the state

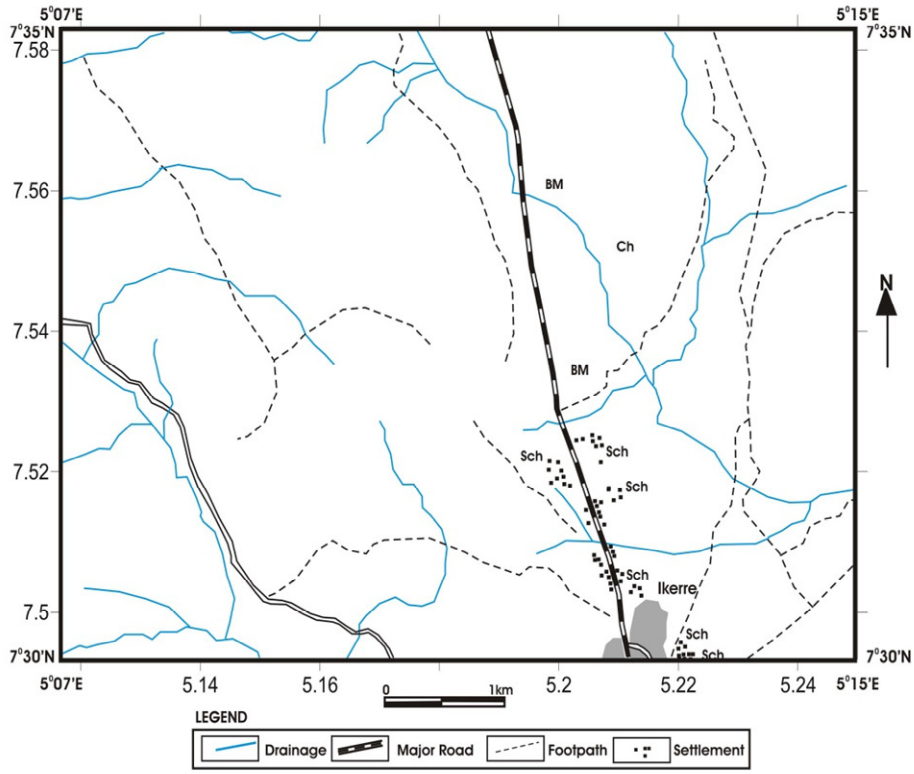

Figure 2. Interconnectivity map of the study area.

capital of Ekiti State) and Akure (the capital of Ondo State), and the nearest gateway to Ekiti state. The town in Ikere-Ekiti is generally accessible through good networks of all seasonal roads and motorable tracks which link it with the neighboring towns and other parts of the country (Figure 2). The villages have major, minor roads and footpaths which makes them not only motorable but accessible to outcrop sites and farmsteads. In the town, the settlement pattern is nucleated with the occupations of the people mainly trading, farming weaving, and hat making.

Local geology of the study area

Ikere-Ekiti and its environs are dominated by crystalline rocks which are composed of migmatite-gneiss quartzite complex, charnockites and fine to medium- grained granites. In the study area, there is a close association between the charnockitic rocks and non-charnockitic granite rocks due to their field relations as documented in the basement complex rocks of Nigeria (Olarewaju, 1988; Hubbard, 1968; Cooray, 1972; Rahaman, 1976).

Migmatite-gneiss-quartzite complex

The migmatite-gneiss is the oldest rock type in the study area. It is widespread, accounting for 80% of the total rocks and appears to be undifferentiated in pattern within the area. It is characterized mostly by alternating light and dark colored bands of minerals such as hornblende or biotite. According to Olarewaju (1981), the quartz and plagioclase feldspars constitute large percentage of the minerals in the light bands. The migmatite gneiss is medium grained and strongly foliated. The quartzites occur as ridges and vary from massive to schistose types. The schistocity is a result of presence of flaky minerals such as mica. Quartz is the dominant mineral in the rock.

Charnockites

The charnockites are other sets of rocks prevalent in the study area. The charnockites occupy more than 75% land mass of Ikere-Ekiti and the outcrops can be found in Ikere-Ise road and comprehensive high school, Ikere-Ekiti. The three main textural types of charnockite are distinguished in the field which agreed with “Olarewaju’s (1988)” classification and are grouped as coarse-grained and fine-medium grained charnockites. Most charnockite bodies in Ikere-Ekiti occurs as low lying outcrops in form of smooth elongated rounded boulders. The charnockite have three mode of occurrence; the first mode of occurrence is that it occurs as cone to an aureole of

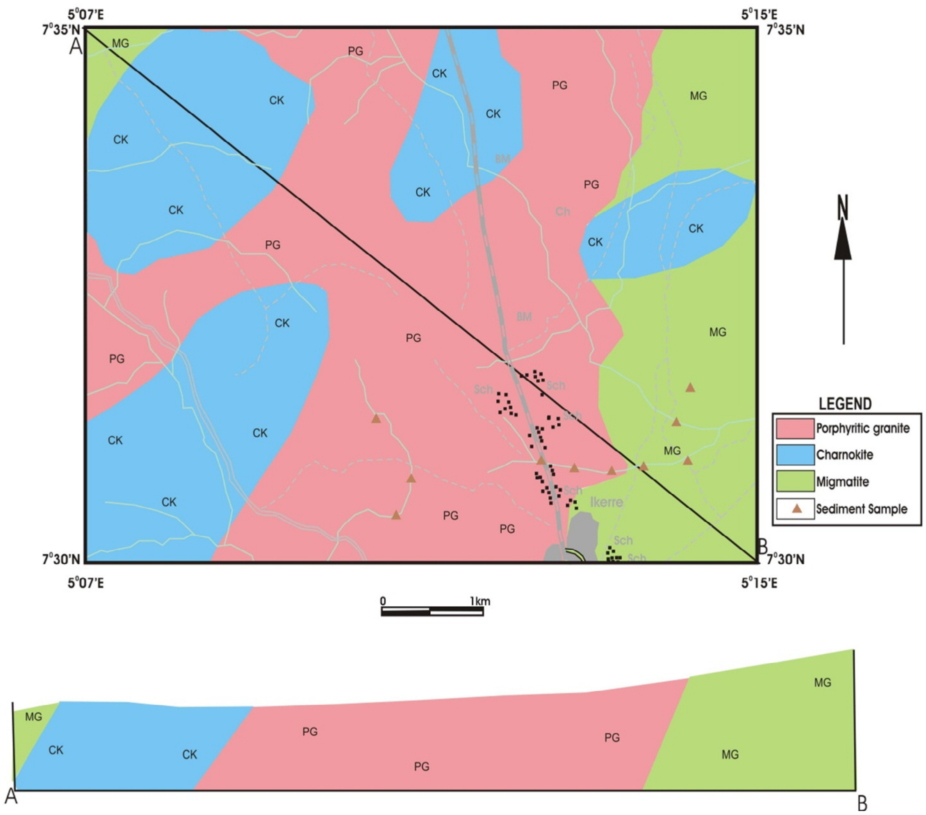

Figure 3. Geological and cross sectional map of Ikere-Ekiti.

granite rocks in which the central area of charnockite is followed by granodiorite, porphyritic biotite and hornblende granite and pegmatites. Charnockites can also occur along the margin of old granite bodies especially biotite and biotite hornblende. The third occurrence is that it occurs as discrete individual bodies within the migmatite gneiss complex. All the rock types are compiled to form geological map of the study area (Figure 3).

METHODOLOGY

Various materials were used for the different aspect of this research, some of the materials include: sample bags used in storing stream sediment samples before it was transported to the laboratory. The samples were carefully labeled with permanent markers to avoid mix up. A set of sieves with perforations of different sizes were also used. The first sieve had 0.150 mm as its aperture size while the second had 2 mm aperture size. These were used in separating sediments of 2 mm and 0.150 fraction sizes from the bulk samples. Other materials included compass clinometers and global positioning system (GPS). The method adopted for this work involves systematic sampling of the stream sediments along stream channels. It involves both field work and laboratory exercises. The field work is essentially geologic mapping. Systematic geological mapping was carried out on a scale of 1:50,000 with grid controlled sampling of the stream sediment channels. Ten stream sediment samples were initially obtained which were representative of the different stream channels. The stream sediment samples were taken at a depth of 20-25 cm, bagged and transported to the laboratory. The process of sample preparation involves pulverizing and homogenizing the stream sediment samples in order to allow it for geochemical analysis. The jaw crusher was used to crush the samples to tiny bits until it became very fine. Methylated spirit was used to cleaning the milling machine after each crushing to avoid contamination. The samples were later digested using the total acid digestion method and placed in a sample container which was properly labeled. The samples were transferred to the laboratory for major, trace and rare earth elements determination. The analyses were carried out at ACME Laboratories East Vancouver, Canada. The analysis involves the use of total acid digestion method for the major element analysis and the use of Multi-collector High Resolution inductively coupled Plasma-Mass Spectrometry (ICP-MS) for the trace and rare earth elements.

Table 1. Stream sediment field data.

Stream names	Location	Latitude/ Longitude	Texture	Remark
Omi Oke-Osun	Okeosun	7°29'6'' N; 5°13'43'' E	Fine and coarse	High stream energy
Omi Igbooko	Aaye	7°29'8'' E	Fine and coarse	The joints on the lithology control the drainage
Omi College	College road	7°29'56'' N; 5°13'45'' E	Fine and coarse	High stream energy
Omi Olafa	Olosunta area	7°29'36'' N; 5°13'45'' E	Fine and coarse	Low stream energy
Omi Oloka		7°30'33'' N; 5°14'2'' E	Fine and coarse	"
Omi Igbongbeyin		7°30'56'' N; 5°14'2'' E	"	"
Omi Okonta	Ijoka	7°29'40'' N; 5°13'45'' E	"	High stream energy
Omi Idegbenyin		7°29'47'' N; 5°13'45'' E	"	High stream energy
Omi College 1	College road	7°29'59'' N; 5°10'3'' E	"	"
Omi College 2		7°28'57'' N; 5°11'13'' E	"	High stream energy

Table 2. Major elements in the stream sediments (%).

Element	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
Al_2O_3	2.45	11.64	8.46	3.65	8.57	13.15	13.43	6.15	16.42	8.27
CaO	0.08	1.60	0.91	0.24	0.58	0.57	1.99	0.41	2.86	0.45
Fe_2O_3	1.13	6.84	4.99	2.33	8.27	6.63	8.89	3.43	11.75	1.58
K_2O	1.19	3.90	2.49	1.16	4.09	3.35	3.42	2.33	3.17	4.25
MgO	0.02	0.82	0.21	0.12	0.22	0.32	1.00	0.07	1.70	0.05
MnO	0.03	0.10	0.10	0.05	0.18	0.11	0.15	0.04	0.19	0.03
Na_2O	0.18	1.44	0.51	0.33	0.60	0.85	1.64	0.61	1.88	0.82
P_2O_5	0.02	0.15	0.26	0.03	0.15	0.08	0.18	0.05	0.34	0.03
SiO_2	92.25	68.22	75.16	88.11	70.46	64.69	58.12	84.52	48.87	81.14
TiO_2	0.18	1.80	1.44	2.27	4.39	3.15	2.86	0.76	3.23	0.80

RESULTS AND DISCUSSION

The field data result of the stream sediments collected in the study area is presented in Table 1. The geochemical analytical results of the major and trace elements are shown in Tables 2 and 3 respectively. The multivariate statistical evaluation and correlation results for the stream sediments are presented in Tables 4 and 5 while the analysis of variance (ANOVA) for the major and trace elements are presented in Tables 6 and 7. The discriminatory diagrams of SiO_2 vs CaO and P_2O_5 vs CaO and are displayed in Figures 4 and 5 respectively. The petrogenetic plot/ternary diagrams for the stream sediments are shown in Figures 6 and 7, while the bar chart showing the distribution of the major and trace elements in the stream sediments are also presented in Figures 8 and 9.

From the results of the geochemical analysis on the stream sediments, the following major elements were analyzed namely: Al_2O_3, CaO, Fe_2O_3, K_2O, MgO, MnO, Na_2O, P_2O_5, SiO_2 and TiO_2 respectively (Table 2). The results revealed that SiO_2 (silica) has the highest concentration in the stream sediments, ranging from 48.87-88.11% with an average value of 73.154%. The highest concentration was discovered in Omi College and Omi Oke-Osunyi, having high concentration values of 84.52 and 68.52% respectively. These showed that the sediments are highly siliceous. The lowest concentration value was detected in Omi Alafa and Omi College with 48.87%. This could be attributed to substitution by a less stable SiO_2 in the mineral framework or as a result of intensive leaching of aluminosilicate minerals such as mica, feldspar, and clay minerals from the parent rock. The concentration values of Al_2O_3 in the stream sediments range from 2.45-16.42% with an average value of 9.23%. The values are high in Omi Alafa and in Igbogbeyin having 13.5 and 16.42% respectively. The abundance of Al_2O_3 indicated the presence of abundant feldspars and micas. Fe_2O_3 concentration values range from 1.13-11.75% with an average value of 5.584%.

Table 3. Trace and rare earth elements in the stream sediments of the study area (ppm).

Elements	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
Mo	0.4	1.2	0.2	1.3	2.0	1.6	1.3	1.3	2.8	0.5
Cu	4.2	19.7	11.9	20.4	12.6	15.7	15.5	15.5	22.5	6.7
Pb	11.4	33.4	17.5	40.0	33.2	24.6	40.2	40.2	27.2	27.3
Zn	8	158	26	129	56	84	65	65	116	11
Ag	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Ni	1.0	10.2	2.7	7.3	12.4	11.8	3.7	3.7	20.9	1.5
Co	1.0	13.1	12.0	3.3	11.2	16.0	16.7	4.0	29.3	2.8
Mn	253	750	751	374	1402	875	1156	358	1556	255
As	0	2	3	0	2	0	2	1	1	0
U	0.7	1.3	1.4	0.8	1.7	3.2	1.7	0.8	2.5	1.1
Au	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Th	5.6	12.3	13.5	10.3	23.3	14.0	7.3	24.0	0.9	5.6
Sr	27	258	147	55	178	141	226	82	313	135
Cd	0	0.1	0	0.3	0	0	0.2	0.3	0	0
Be	0	1	2	0	1	3	3	0	3	1
Sc	0	9	5	2	5	8	11	2	17	4.4
Li	2.3	11.7	7.5	3.6	4.6	13.0	11.8	4.4	16.8	110.9
Rb	37.3	109.7	69.1	28.6	100.8	121.0	123.6	61.5	119.6	1.1
Hf	1.8	1.2	1.0	1.1	2.9	3.8	2.4	0.6	3.8	0
Sb	0	0	0.7	0	0.3	0	0	0.6	0	0
Bi	0	0	0	0	0	0	0	O	0	22
V	13	87	63	26	27	93	96	30	146	16.0
La	8.0	56.6	39.9	28.6	28.7	69.4	72.3	18.5	110.6	16.0
Cr	8	17	18	23	40	33	22	24	28	13
Mg	0	0.48	0.12	0.03	0.12	0.17	0.56	0.04	0.96	0.03
W	0.2	0.6	0.7	1.2	1.2	0.9	0.5	1.2	0.5	0
Zr	46.1	36.9	33.9	39.1	94.1	139.3	78.1	20.2	120.9	39.5
Ce	19	109	99	56	123	175	139	109	22	50

Sample 1, Omi College; Sample 2, Omi College 1; Sample 3, Omi College 2; Sample 4, Omi Igbo-Oko; Sample 5, Omi Ikonto; Sample 6, Omi Idegbenyin; Sample 7, Omi Ogbegbeyin; Sample 8, Omi Oke Osunyi; Sample 9, Omi Alafa; Sample 10, Omi Olonta.

However, the stream sediment from Omi Alafa is moderately enriched with Fe_2O_3. This may be as a result of the oxidizing conditions the sediment might have gone through or as a result of moderately to low concentration of iron-bearing minerals in the parent rock. CaO values range from 0.08-2.86% with an average value of 0.969%. The CaO content of sediments from Omi Alafa and Omi Igbogbeyin are low when compared to Omi Oke-Osunyi, Omi Olonta, with their concentration values at 0.41% and 0.45% respectively which are very low and close to each other. This could be an indication of the calc-alkaline precursor of the surrounding rocks. K_2O and Na_2O values range from 1.19-4.25% and 0.18-1.88% respectively. This indicated that clay minerals may be present in relatively small proportion and the broken down feldspars might have leached away. MgO values range from 0.02-1.70% with an average value of 0.453%. Stream sediments from Omi Alafa and Omi Igbogbeyin contains 1.77 and 1.00% of MgO which is low when compared with other stream sediment samples from Omi College (0.002%), Omi Oke-Osunyi (0.007%) and Omi Olonta (0.005%) indicating very low concentration of MgO. These sediments are likely to be derived from parent rocks containing moderate to low concentration of amphibole, olivine and serpentine. Some of the trace elements analyzed in the stream sediments are Ba, Mg, Ce, Sr, V, Zr, Pb, Cr, Ni, Zn, Pb, Cu and Mo (Table 3). Lead (Pb) ranges from (11.4-40.2) ppm with average values of 5.584 ppm. Pb is one of the most important decay products of U and Th, and content is high in the stream sediments from Omi Igbogbeyin and Omi Oke-Osunyi with average values of 40.2-40.2 ppm respectively. The Pb content in the sediments indicated the presence of heavy metals in sediments and the tendency to be radioactive. Ba (barium) content in the samples ranges from 186-1308 ppm with average

Table 4. Multivariate statistical evaluation

Element	Minimum	Maximum	Mean	Median	St. Deviation	Skewness	Kurtosis
Al_2O_3	2.45	16.42	9.22	8.52	4.46	0.015	-0.79
CaO	0.08	2.86	0.967	0.58	0.897	1.26	0.781
Fe_2O_3	1.13	11.75	5.58	5.81	3.501	0.31	-0.84
K_2O	1.16	4.25	2.94	3.26	1.116	-0.63	-0.81
MgO	0.02	1.7	0.45	0.22	0.55	1.568	1.906
MnO	0.03	0.19	0.1	0.1	0.061	0.337	-1.35
Na_2O	0.18	1.88	0.89	0.72	0.575	0.701	-0.81
P_2O_5	0.02	0.34	0.13	0.12	0.108	0.872	-0.09
SiO_2	48.87	92.25	73.2	72.8	13.76	-0.33	-0.64
TiO_2	0.18	4.39	2.09	2.035	1.33	0.214	-0.8
Mo	0.2	2.8	1.26	1.3	0.781	0.535	0.411
Cu	4.2	22.5	14.5	15.5	5.836	-0.49	-0.39
Pb	1.13	11.75	5.584	5.81	3.5	0.31	-0.8
Zn	1.16	4.25	2.935	3.26	1.12	-0.63	-0.8
Ag	0.02	1.7	0.453	0.215	0.55	1.568	1.91
Ni	0.03	0.19	0.098	0.1	0.06	0.337	-1.4
Co	0.18	1.88	0.886	0.715	0.58	0.701	-0.8
Mn	0.02	0.34	0.129	0.115	0.11	0.872	-0.1
As	48.87	92.25	73.15	72.81	13.8	-0.33	-0.6
U	0.18	4.39	2.088	2.035	1.33	0.214	-0.8
Au	0.2	2.8	1.26	1.3	0.78	0	0
Th	4.2	22.5	14.47	15.5	5.84	-0.49	-0.4
Sr	11.4	40.2	29.5	30.25	9.85	-0.59	-0.5
Cd	8	158	71.8	65	50.6	0.355	-0.9
Be	0	0.01	0.001	0	0	3.162	10
Sc	1	20.9	7.52	5.5	6.32	1.04	0.73
Li	1	29.3	10.94	11.6	8.65	0.906	0.94
Rb	253	1556	773	750.5	476	0.479	-1.1
Hf	0	3	1.1	1	1.1	0.388	-1.2
Sb	0.7	3.2	1.52	1.35	0.8	1.158	0.88
Bi	0	0	0	0	0	0	0
V	0.9	24	11.68	11.3	7.51	0.548	-0.4
La	27	313	156.2	144	90.4	0.31	-0.6
Cr	0	0.3	0.09	0	0.13	1.009	-0.8
Mg	0	3	1.4	1	1.26	0.28	-1.7
W	0	17	6.34	5	5.06	0.971	0.92
Zr	2.3	110.9	18.66	9.6	32.8	3.038	9.42
Ce	1.1	123.6	77.23	84.95	44.1	-0.51	-1.2
Sn	0	3.8	1.86	1.5	1.32	0.367	-1.1
Y	0	0.7	0.16	0	0.28	1.437	0.48
Nb	0	22	2.444	0	7.33	3	9
Ta	13	146	59.7	46.5	44.5	0.731	-0.4
In	8	110.6	44.86	34.3	32.1	0.928	0.37
Re	8	40	22.6	22.5	9.43	0.378	0.06
Se	0	0.96	0.251	0.12	0.32	0	0
Te	0	1.2	0.7	0.65	0.42	0	0
Ti	20.2	139.3	64.81	42.8	41	0.884	-0.6
Ba	19	175	90.1	104	51.6	-0.0	-0.9

Table 5. Correlation of elements.

	MO	Cu	Pb	Zn	Ni	Co	Mn	V	Nb	Ta	Ba	Zr	Rb
MO	1												
Cu	0.704	1											
Pb	0.412	0.59	1										
Zn	0.582	0.91	-0.54	1									
Ni	0.912	0.71	0.146	0.64	1								
Co	0.713	0.62	0.045	0.43	0.791	1							
Mn	0.764	0.49	0.147	0.31	0.767	0.88	1						
V	0.599	0.67	0.061	0.52	0.689	0.95	0.715	1					
Nb	0.679	0.21	0.08	0.1	0.629	0.69	0.867	0.53	1				
Ta	0.679	0.36	0.13	0.21	0.657	0.82	0.565	0.72	0.95	1			
Ba	0.503	0.4	0.262	0.33	0.564	0.72	0.778	0.63	0.71	0.801	1		
Zr	0.698	0.29	0.992	0.18	0.723	0.72	0.724	0.62	0.84	0.843	0.476	1	
Rb	0.631	0.55	0.181	0.47	0.64	0.82	0.824	0.8	0.81	0.86	0.689	0.671	1

Table 6. ANOVA of major elements in the stream sediments. Anova: Two-Factor without replication.

Summary	Count	Sum	Average	Variance		
Al_2O_3	10	92.19	9.219	19.89452		
CaO	10	9.69	0.969	0.803788		
Fe_2O_3	10	55.84	5.584	12.25407		
K_2O	10	29.35	2.935	1.246317		
MgO	10	4.53	0.453	0.303046		
MnO	10	0.98	0.098	0.003662		
Na_2O	10	8.86	0.886	0.330671		
Omi College	10	97.53	9.753	840.8468		
Omi College 1	10	96.51	9.651	436.5127		
Omi College 2	10	94.53	9.453	540.1543		
Omi Igbo Oko	10	98.29	9.829	758.0793		
Omi Ikonto	10	97.51	9.751	465.8255		
Omi Idegbeyi	10	92.9	9.29	395.6609		
Omiogbegbeyin	10	91.68	9.168	313.8211		
Omi Oke Osunyi	10	98.37	9.837	692.4564		
Omi Alafa	10	90.41	9.041	223.7552		
Omi Olonta	10	97.42	9.742	636.1228		
ANOVA						
Source of variation	SS	df	MS	F	P-value	F crit
Rows	45702.97	9	5078.107	203.0092	1.02E-51	1.997609
Columns	7.708765	9	0.856529	0.034242	0.999996	1.997609
Error	2026.148	81	25.01417			
Total	47736.82	99				

concentration of 90.1 ppm showing very high concentration. However, stream sediments taken from Omi College and Omi Ikoto showed high values ranging from 1307-1308 ppm respectively. High Ba content could be as a result of the derivation of the elements from pre-existing rocks through anatectic process. Chromium (Cr) content ranges from (8-40) ppm with average values of 0.09 ppm; the moderately high Cr concentration are found in Omi Ikonto and Omi Idegbeyin with values at 40 and 33 ppm respectively. These showed that the concentration of chromium is very moderate. Chromium is a good plating material for kitchen and house hold

Table 7. ANOVA of trace elements in the stream sediments. ANOVA: Two-Factor without replication.

Summary	Count	Sum	Average	Variance		
Mo	10	12.6	1.26	0.609333		
Cu	10	144.7	14.47	34.06456		
Pb	10	295	29.5	97.09778		
Zn	10	718	71.8	2556.844		
Ba	10	9110	911	156178		
Ni	10	75.2	7.52	39.95067		
Co	10	109.4	10.94	74.81378		
Sc	10	63.4	6.34	25.60044		
Li	10	186.6	18.66	1073.249		
Rb	10	772.3	77.23	1948.849		
Hf	10	18.6	1.86	1.744889		
Th	10	116.8	11.68	56.34622		
Sr	10	1562	156.2	8166.844		
Zr	10	648.1	64.81	1678.388		
Ce	10	901	90.1	2659.878		
V	10	597	59.7	1978.678		
La	10	448.6	44.86	1027.92		
Cr	10	226	22.6	88.93333		
Sn	10	39.6	3.96	5.544889		
Y	10	150.9	15.09	189.1677		
Nb	10	496.8	49.68	892.7729		
Ta	10	25.1	2.51	2.992111		
Omi College	22	412	18.72727	1562.246		
Omi College 1	22	2318.6	105.3909	76002.81		
Omi College 2	22	1525.5	69.34091	36497.13		
Omi Igbo Oko	22	902.3	41.01364	7802.599		
Omi Ikonto	22	2181.5	99.15909	75168.97		
Omi Idegbeyi	22	2063.8	93.80909	42653.8		
Omiogbegbeyin	22	2236.5	101.6591	63196.56		
Omi Oke Osunyi	22	1131.1	51.41364	14960.78		
Omi Alafa	22	2510.3	114.1045	70593.69		
Omi Olonta	22	1436.1	65.27727	41181.02		
ANOVA						
Source of variation	SS	df	MS	F	P-value	F crit
Rows	7613112	21	362529.2	48.6323	1.08E-64	1.612115
Columns	200105.3	9	22233.93	2.982621	0.002412	1.929689
Error	1408899	189	7454.493			
Total	9222117	219				

utensils. Cerium (Ce) values ranges from (19-175) ppm, with average of 77.23 ppm and with highest concentration in Omi Igbogbeyin (175 ppm) and the lowest concentration in Omi College (19 ppm). These earth elements analyzed are: La, W, Nb and Si. La content in the samples analyzed was extremely high when compared with other rare-earth elements. La content ranges from (8.0-1106) ppm with average values 156.2 ppm. It is the only rare earth element detected in the stream sediments samples from the study area, and accounted for relatively high concentration in stream sediments from Omi Igbogbeyin and Omi Olata with average concentration of 110.6-72.3 ppm respectively.

Statistical evaluation of the standardized geochemical

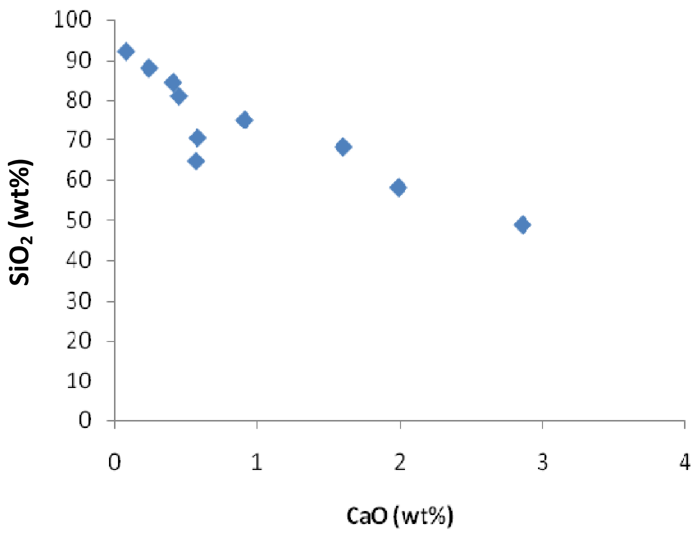

Figure 4. Discriminant diagram of SiO_2 vs CaO plot.

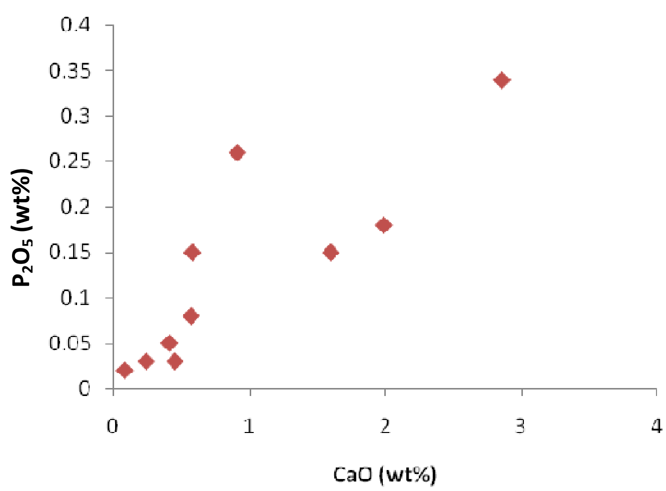

Figure 5. Discriminant diagram of P_2O_5 vs CaO plot.

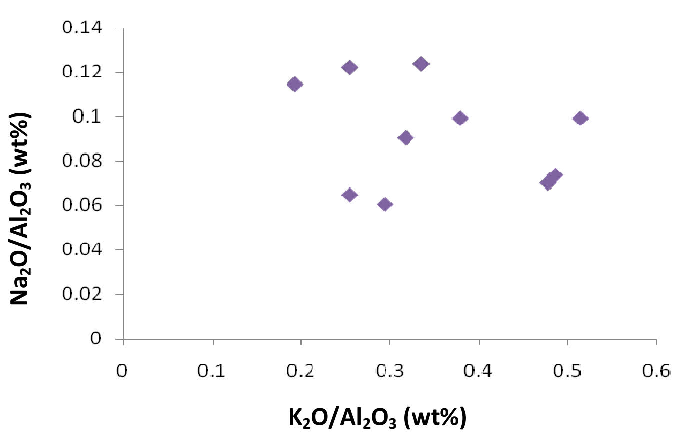

Figure 6. Discriminant diagram of Na_2O/Al_2O_3 vs K2O/ Al_2O_3 plots (Garrels and Mackenzie, 1971).

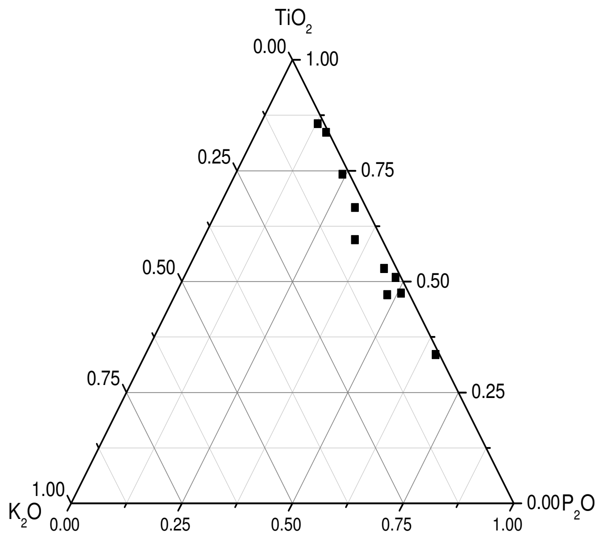

Figure 7. TiO_2-K_2O-P_2O_5 plot of Stream sediments from Ikere-Ekiti.

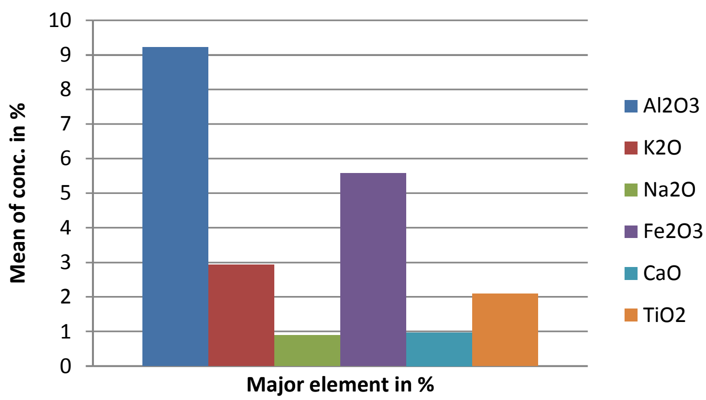

Figure 8. Bar chat of mean concentration against major elements.

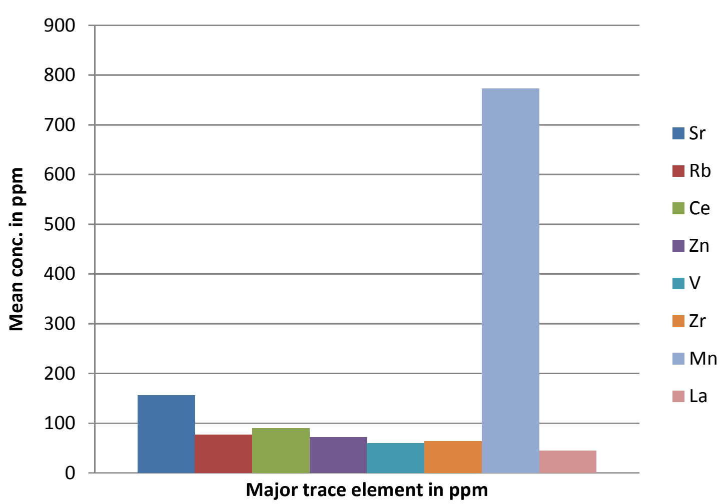

Figure 9. Bar chat of mean concentration against trace elements.

results was carried out using Software Package for Statistical Simulation (SPSS) window version 17.0. Also, K_2O and SiO_2 show negative skewness and kurtosis whereas, trace elements such as Cu, Zn, etc also displayed negative skewness and kurtosis indicating a peaked distribution to the left (Table 4). Also, Cu, Pb, Ni, Co, Mn, Va, Nb, Ta, Ba, Zr and Rb show positive correlation to another except zinc which is negatively correlated with Pb (Table 5) which is also an indication of abundant heavy metal presence in the stream sediments. In the analysis of variance (Tables 6 and 7), the F-value is greater than F-critical for the rows (sampling sites) than the columns (elements) for both major and trace elements which is an indication that both (major and trace) elements obeyed the hypothesis of no difference which confirmed that the sampling sites apart from the elements contributed to the geochemical differences and anomalies in the study area. On the SiO_2 vs CaO discrimination diagram (Figure 4), an overall negative correlation is higher in the SiO_2/CaO ratio in the siliceous rich stream sediments. Also, the variation trend displayed may be parallel to the degree of differentiation or chemical maturity of the parent rocks. On the P_2O_5 vs CaO discrimination diagram (Figure 5), the relationship between both elements is presumably significant and there is a positive correlation. In addition, the Na_2O/Al_2O_3 vs K_2O/Al_2O_3 diagram (Garrels and Mackenzie, 1971; Figures 6 and 7) showed that the stream sediments are largely of igneous origin, while the bar chart showing mean concentration against elements is presented in Figures 8 and 9 respectively.

Conclusion

From the results of the geochemical analysis, stream sediments in the areas of study are generally enriched in SiO_2 (siliceous >65%) thereby reflecting the crystalline nature of the parent rocks. The highest value of SiO_2 was discovered in the samples collected from Omi College and Omi Oke-Osunyi locations. This confirmed that all the analyzed stream sediment samples are derived from highly siliceous rocks such as granites, quartzites and the migmatite gneisses in the studied areas. In addition, sediments collected from Omi College, Omi Igbogbeyin and Omi Oke-Osunyi localities show promising sites for detailed geochemical exploration for radioactive minerals such as Rb and Zr, heavy metals such as Cu, Pb, Zn and cobalt, and base metals such as Ni, and Mn respectively. The presence of moderate to large concentrations of toxic/heavy metals in the stream sediments such as Cadium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb) and zinc (Zn) may contribute significantly to various health hazards associated with heavy metal consumption in streams; for instance, cadmium exposure causes degenerative acute borne disease and finally death after long term consumption. Also, some of the radioactive elements present in the stream sediments are useful in energy provision and protein ware fare business. However, they may produce x-ray which can cause skin cancer or mutations. It can also affect some sense organs such as the gonad.

Recommendations

Detailed heavy mineral analysis and its level of pollution in surface water and hand dug wells in the study area should be carried out since there is anomalous concentration of heavy metals in the stream sediments analyzed in the studied areas which portends danger to human lives since most of the inhabitants depend largely on stream/surface water for human and domestic consumption. Heavy mineral assessment in the surface and hand dug wells will assist in determining the level of contamination by the toxic elements and adequate preventive measures put in place.

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