Volume 1 No.6, December 2011 ISSN 2224-3577
International Journal of Science and Technology

http://www.ejournalofsciences.org

Stream Sediment Geochemical Survey of Ara, Epe and Ijero Area, South Western Nigeria

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ABSTRACT

Ara, Epe and Ijero Ekiti lies within the migmatite-gneiss-quartzite complex of the basement complex of Southwestern Nigeria, between latitudes 7^{0} 45' to 7^{0} 55" to longitudes 5^{0} 00' to 5^{0} 10'. Thirteen stream sediment samples were collected at the confluence points of two or more rivers mostly at a depth of 20-25cm, while seven (7) representative samples were systematically picked and analyzed for major, trace and rare earth elements concentration using ICP-MS analytical method. The results of the geochemical analysis were thereafter subjected to multivariate statistical analysis. The statistical plot shows that most elements have their peak in the northwestern part of the study area (Ijero). The conclusion drawn from the integration of the geochemical and multivariate analyses revealed that the study area is mineralized in phosphate minerals, probably monazite, turquoise, or apatite; ferruginous minerals which could be hematite and manganese-bearing minerals such as manganite or mica rich manganese. These mineralizations are hosted by the pegmatites that intrude the country rocks in the northwestern part of the study area.

Keywords: *Ara, Epe, Ijero, Stream sediments, Geochemistry, Statistics*

1. INTRODUCTION

The world economy at present is growing at a rate that necessitates an increasing demand for rare metals, with this trend likely to continue into the future (Patrick De St. Simmon, 1999). In recent times there has been a resurgence of interest in the study of rare metal pegmatite occurrence in Nigeria (Garba, 2002; Okunlola, 2005, 2008; Okunlola and Jimba, 2006; Okunlola and Oyedokun, 2009; Oden, 2010). Granite pegmatite is one of the classical sources of a broad spectrum of rare earth elements: Sn, Nb, Ta, U and Th (Cerny, 1994). In Nigeria, Pan African intrusive suites which comprise mainly granites, granodiorites and tonalites are intruded by numerous veins of pegmatite and aplites (Okunlola et al; 2005). The pegmatites belong to the terminal stage of Pan-African magmatism (Rahaman et al., 1998 and Elueze, 2002). Systematic field mapping by (Okunlola et al; 2005) reveals that the Precambrian pegmatites of Ijero area are hosted by biotite-gneiss and biotite Schist. Petrographic analysis also shows that they contain mainly quartz, plagioclase feldspar, microcline and muscovite with accessory biotite, hornblende and tourmaline. From geochemical studies of the muscovite extracts, the pegmatites are siliceous, with a paraluminous composition, while trace elements analysis indicate that the pegmatite are variably enriched in rare metals such as Ta, Nb including Li, Rb and Sr. variation plots for Ta versus K/Cs, Ta/W versus Cs, Ta versus Ga, Na/K versus Sn, Nb. Ta of the samples indicate a lower mineralization potentials when compared to Tanco pegmatite (Canada), Nassarawa-Keffi pegmatite field of Nigeria, but are comparable to those of Wodgnia pegmatite (Australia), Hergendorf pegmatite (Western Germany) and Noumas pegmatite (South Africa). In addition to the major and minor element compositional features, consistent negative Eu signature of the chondrite normalized rare earth elements plots suggest the possibility of Ijero area pegmatites being derived from anatexis of undepleted upper to middle crustal protoliths or supracrustal with possible later metasomatic alterations.

Also, the geology of the study area has been well studied and reported as part of Ijero area and also reported as part of Southwestern Nigeria Basement Complex (Rahaman et al 1988 and Oyinloye 1997). According to Oyinloye and Adebayo (2005), the migmatite-gneiss complex in the area is composed of a mafic portion made up of biotite, hornblende, quartz and Opaque minerals, while the felsic portion is quartzo-feldspartic. Other rocks identified by these authors are: charnockites, metasediments composed of amphibolites schist, mica schist and quartzites. Geochronological work carried out by Matheis and Caen-Vachette (1983) using the Rb-Sr methods of dating on the muscovite, biotite and Oligoclase from minerals are: 487±14ma, 183±15ma and 532 ± 16ma respectively with initial Sr 87-86 ratio of 0.712 for the three minerals.

However, heavy metals are natural constituents of the earth's crust, but human activities have drastically altered their geochemical cycles and biochemical balance (Giachetti and Sebastiani, 2006), Mining activities all over the world have contributed immensely to this observed disequilibrium and affect the terrestrial ecosystem due to the excavation of large amount of sand and eventually accumulation at large concentration of heavy metals in the extraction processes, which tend to increase the natural metal content of the soil. These heavy metals are transported via erosion into streams and rivers. Geological field mapping and geochemical study of the area were carried out on the basement rocks and stream sediments in Epe, Ara and Ijero-Ekiti in Ekiti State with the aim of determining the underlying lithologic units and the heavy minerals likely to be found in the stream sediments and; to

ISSN 2224-3577
International Journal of Science and Technology

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provide a baseline geochemical data for further geochemical investigation of the area.

2. LOCATION OF THE STUDY AREA AND ACCESSIBILITY

The study area falls within the Basement complex of Southwestern Nigeria. Ara, Epe and Ijero Ekiti are characterized by the abundance of pegmatites which harbors minerals such as gem-stones and rare earth metals as well as metallic-ores such as lepidolite among other minerals. The study area falls within Latitudes 7^{0}.45N to 7^{0}55N and Longitudes 5^{0}00E to 5^{0}10E (Fig.1) East of the green which meridian. It is part of the West African Craton in the region of the late Precambrian to Early Paleozoic Orogenesis. Other towns around the study area include Aramoko, Ikoro, Aiyegunle, Ipoti, and Oke-Asa, with Aiyegunle in the Northeast, Ikoro in the Northwest and Oke-Asa in the Southwest. The study area can be rated moderately accessible due to the road network systems which include the major and minor roads and also footpaths which link the study area.

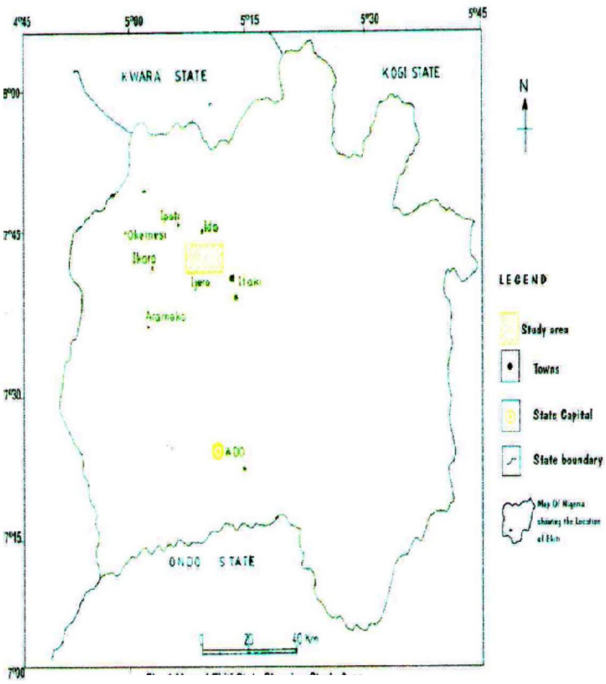

Fig 1: Map of Ekiti State showing the Study Area

3. TOPOGRAPHY AND DRAINAGE

The study area is a rugged terrain with series of highlands, lowlands and massive rocks with steep and gentle slopes. The rugged terrain is brought about by the pegmatite and granitic intrusion into the schist and migmatite-gneiss complex. Due to the agent denudation, the schist have been reduced to low-lying plains while the pegmatites and gneisses forms hills that stretches from Ijero to Ara and Epe. The migmatites, gneisses and quartzites constitute an undulating topography around Ara. The hills are separated by valleys and gullies which accumulate water during rainy season flowing down streams to erode and expose the underlying rocks, and carries weathered residues including minerals down the slope into streams and rivers (Fig.2). The streams spread out from a central point forming dendritic drainage pattern. The major rivers in the study area includes: River Awo and River Orile which spreads throughout the study area.

4. GEOLOGIC SETTING OF THE STUDY AREA

Ara, Epe and Ijero area within the Ijero pegmatite field lies within the Precambrian basement of Southwestern Nigeria. The basement rocks of Nigeria form part of the extensive Pan-African province of West Africa and are delimited in the West by the West African Craton and in the East by the Congo Craton. Based on lithological associations and geochronological delineations, the Nigeria basement complex comprises the Migmatite-gneiss-quartzite complex, the Schist belts and the Older Granites. The Migmatite-gneiss-complex is the oldest, most widespread and abundant rock type in the Basement (Ogezi,1988). It is of Archean-Proterozoic and possibly Undergone polycyclic evolutionary histories. The Nigerian Schist belts comprise of low-grade metasediments and metamorphosed pelitic and psammitic assemblages that outcrop in a series of N-S trending synformal troughs infolded into the crystalline complex of migmatite gneiss. The Pan-African Granites referred to as Older Granite include rocks of wide range of composition varying from tonalite, granodiorite, granite and syenite (Rahamian et al., 1988). The pegmatite from Ijero area form an intrusion into the older rock of biotite gneiss that occupies the central part of the area, covering about three quarter of the total land mass (Fig.3). The schistose rock is greyish, highly foliated and weathered. The topographical configurations are essentially low-lying discontinuous outcrops that have a westerly dip values ranging between 25^{0} and 30^{0}. Mineralogically, they are composed of quartz, biotite and hornblende, while accessory minerals include apatite and Opaques. Biotite-gneiss occupies the north central area and extends towards the northwestern direction. Outcrops of the rock are low-lying, highly foliated with characteristics black tints imposed by the preponderance of biotite. The pegmatites comprise quartz (30^{0}%), albite (27%), muscovite (14%) and microcline (14%) while biotite (1.0%), hornblende (2.8%) and tourmaline (3.2%) minerals occur in subordinate amount. Quartz occurs as irregular masses of euhedral crystals. Microcline occurs as phenocrysts with characteristic strong crosshatched twinning and variable microperthitic intergrowth while carlsbard- twinning and albite twinning characterizes the albite. Muscovite occurs as large platy grains. Accessory minerals include tourmaline and biotite. The tourmaline crystals exhibit long needle-like prismatic shapes with their long axis aligned parallel to each other.

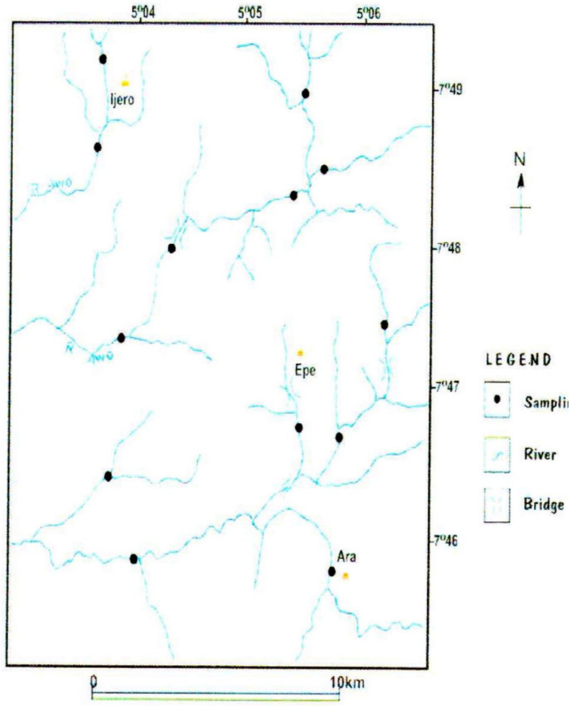

Fig 2: Drainage Map of the Study Area Showing the Sampling Points

5. LOCAL GEOLOGY OF THE STUDY AREA

The study area is characterized by lithologies such as pegmatites, biotite gneisses, quartzites, migmatite-gneisses. (Fig.3). The pegmatites intruded the biotite gneiss and migmatite gneiss that occupies the central part of the study area, covering about three-quarter of the total landmass. The pegmatites are very coarse-grained with phenocrysts over 2500mm in length, usually of granitic composition and forming at a late stage of crystallization. Pegmatites are one of the classic broad spectrums of rocks hosting rare-metals. Many exotic elements are discovered in pegmatites such as lithium, rubidium, cesium, berylium, gamalium, scandian and rare earth elements including Tn, Sn, Nb, Ta, Th, Zr, Hf, etc. Micas are also available. The biotite- gneisses are highly foliated with alternating bands of black tints imposed by biotite impregnations, alongside felsic minerals such as quartz and feldspar. Most of the mineral alignments are conformable with the foliation planes of the adjacent schistose rocks. The biotite gneiss occupies the north central area and extends towards the northwestern direction. They are usually medium to coarse grained; foliated and largely crystallized which are likely to form under high temperature and pressure conditions. The quartzites in the study area might have formed in two different ways; It could have formed under high pressure of deep burial of sandstone or chert which recrystallizes and results in a metamorphic rock or from sandstone at low temperature and pressure, where circulating fluids fill the spaces between the sand grains with silica cement. This kind of quartzite is also called orthoquartzite. The quartzites in the study area are the massive and schistose types with some impregnations of smoky quartz and mica. The migmatite- gneiss is the oldest of the rock types in these areas. It is not widely distributed in the study area compared to the pegmatites, and it is characterized mostly by alternating light and dark colour bands. The migmatite shows irregular banding and much crystallization. It is typical of metamorphic gneiss that has taken an igneous character through partial melting and have mineralogical composition of quartz, orthoclase feldspar, hornblende, muscovite and biotite. The migmatite occupy the northern trend in the study area.

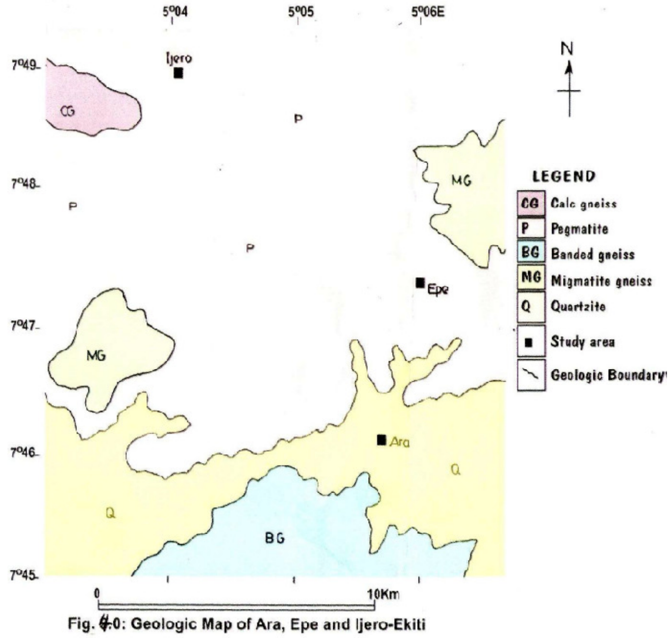

Fig 3: Geological Map of the Study Area

6. MATERIALS AND METHODS

Relevant data, materials, abstracts and maps for the different aspects of these studies were collected from sources such as Ministry of Works, Akure, Ministry of Works, Ado-Ekiti and the School of Earth and Mineral Sciences, Department of Applied Geology, Federal University of Technology, Akure. (FUTA). Geologic mapping of the study area was carried out at a scale of 1:50,000 using the topographic map sheet of the study area with grid controlled sampling of the streams, coupled with the Global Positioning System (GPS) for locating accurately on the map, the geographic positions of the outcrops and streams. Other materials included compass clinometers for navigation and measuring strike and dip directions, sample bags, sieves of different mesh sizes, hand trowel for scooping the sediments, masking tape and markers for labeling of samples to avoid mix up and field notebook for recording field observations. Thirteen samples were initially obtained, while seven which were representative of the different stream obtained from Ara,

Volume 1 No.6, December 2011 ISSN 2224-3577
International Journal of Science and Technology

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Epe and Ijero-Ekiti were eventually analyzed. Three fresh and uncontaminated samples were obtained from streams around Ijero being the largest while two samples each were collected from streams around Ara and Epe respectively. The stream sediments collected were taken to the laboratory for geochemical analysis. The sediments were pulverized using a milling machine which worked continuously until the samples became very fine. The samples were later placed in a container and properly labeled and finally sent to ACME Laboratories, East Vancouver, Canada for analysis. The method of digestion adopted is the Lithium borate method. The major, trace and rare earth elements in the stream sediments were analyzed using inductively coupled plasma-mass spectrometry (ICP-MS)

7. RESULT AND DISCUSSION

Table 1: Major Elements in Stream Sediments

Locations	Al (%)	Ca (%)	Fe (%)	K (%)	Mg(%)	Na (%)	S (%)	Ti (%)
1	0.14	0.01	0.42	0.02	0.02	0.01	<0.01	0.016
2	0.27	0.04	1.54	0.03	0.02	0.02	<0.01	0.039
3	0.21	0.02	0.25	0.06	0.03	0.02	<0.01	0.017
4	0.13	<0.01	0.22	0.03	0.01	0.02	<0.01	0.017
5	0.16	0.02	0.83	0.03	0.02	0.02	<0.01	0.077
6	0.13	<0.01	0.13	0.03	0.01	0.02	<0.01	0.011
7	0.43	0.09	1.86	0.06	0.04	0.02	<0.01	0.033
Average	0.21	0.077	0.776	0.037	0.0214	0.017	0.009	0.03

Table 2: Trace Elements and Rare Earth Elements in (ppm)

Location	Cd (ppm)	Ga (ppm)	La (ppm)	P (ppm)	Cs (ppm)	Th (ppm)	U (ppm)	W (ppm)	Y (ppm)	Sn (ppm)	Sr (ppm)	Sc (ppm)	Mo (ppm)	Nb (ppm)	Re (ppm)	Ta (ppm)	Te (ppm)	Tl (ppm)	Ti (ppm)	Se (ppm)
1.	0.01	0.74	4.2	60	0.16	2.7	0.51	<0.05	1.69	0.3	2.6	0.7	0.11	0.5	<0.001	<0.01	<0.01	0.03	0.016	<0.2
2.	0.01	2.16	11.7	80	2.91	6.7	3.22	0.14	2.35	1.7	4	1.3	0.24	2.32	<0.001	<0.02	<0.01	0.12	0.039	<0.2
3.	0.05	0.89	3.3	70	0.76	1.8	2	0.06	1.07	0.9	2.1	0.8	0.08	0.93	<0.001	<0.01	<0.01	0.1	0.017	<0.2
4.	0.01	0.67	6.7	40	1.0	3.9	2.39	0.1	1.24	1.1	0.9	0.7	0.05	1.06	<0.001	<0.01	<0.01	0.06	0.017	<0.2
5.	0.01	1.23	15.3	90	0.17	9.1	1.36	<0.05	3.77	0.6	3	1.1	0.15	1.1	<0.001	<0.01	<0.01	0.03	0.077	<0.2
6.	0.01	0.72	5.2	50	0.13	3.4	0.51	<0.05	1.61	0.3	1.5	0.6	0.11	0.47	<0.001	<0.01	<0.01	0.03	0.011	<0.2
7.	0.01	2.45	12.3	420	1.13	5.9	1.04	0.18	3.48	3.5	7.4	2.6	0.39	0.55	<0.001	<0.01	<0.01	0.08	0.033	<0.2
Average	0.021	1.27	8.4	115.7	22.38	4.79	1.56	0.089	2.173	1.2	3071	1.11	0.15	0.977	0.0009	0.0006	0.009	0.06	0.03	0.193

Table 3: Statistical table for Major Elements in the Stream Sediment of the Study Area

Element (%	Range	Mid point	Mean	Mode	Median	Mean deviation	Variance	Standard deviation	Kurtosis	Skewness
Al	0.43-0.13	0.035	0.210	0.43	0.16	1.26	0.265	0.51	6.21	2.51
Ca	0.09-0.01	0.05	0.771	0.09	0.02	0.93	0.144	0.38	6.00	2.45
Fe	1.86-0.22	1.04	0.7757	1.86	0.42	4.65	3.61	1.90	6.35	2.45
K	0.06-0.02	0.025	0.0371	0.06	0.03	0.115	0.0022	0.047	5.97	2.45
Mg	0.04-0.01	0.015	0.0214	0.04	0.02	0.129	0.0028	0.053	5.75	2.38
Na	0.02-0.01	0.01	0.0174	0.2	0.02	0.103	0.0018	0.042	5.79	2.43
S	0.01-0.01	0.01	0.009	0.009	0.009	0.054	0.00049	0.022	5.90	2.50
Ti	0.077-0.011	0.044	0.03	0.077	0.017	0.18	0.0054	0.74	6.1	2.40

Table 4: Statistical Table for Trace and Rare Earth Elements in the Stream Sediment of Study Area

Element (%)	Range	Mid point	Mean	Mode	Median	Mean deviation	Variance	Standard deviation	kurtosis	Skewness
Ag	0.03-0.01	0.02	0.0153	0.03	0.07	0.0918	0.0014	0.038	5.46	2.41
As	0.6-0.1	0.35	0.21141	0.6	0.1	1.4559	0.035	0.59	6.01	2.50
Au	0.2-0.2	0	0.19	0.019	0.019	1.14	0.2166	0.47	5.77	2.38
B	10-10	0	9	9.9	9.9	54	486	22.1	5.94	2.43
Ba	50-10	30	22.86	50	50	137.14	3134.6	35.98	6.0	2.45
Be	0.53-0.39	0.69	0.41	0.98	20	2.46	1.00	1.00	6.0	2.48
Bi	0.53-0.091	0.31	0.1586	0.53	0.42	1.2514	0.26	0.51	6.0	2.46
Ce	33.8-6.96	20.39	22.38	46.5	0.09	134.28	30.05	54.8	6.0	2.45
Co	5.2-0.9	3.05	2.586	5.2	14.95	15.51	40.12	6.3	6.13	2.49
Cr	63-4	33.5	18.571	63	2.1	111.43	2069.4	45.5	5.99	2.45
Cs	2.91-0.16	11.75	0.9086	2.91	9	5.45	4.45	2.22	6.06	2.47
Cu	39.5-3.1	21.3	11.0	39.5	0.76	66.17	27.0	27.0	6.01	2.45
Ge	0.08-0.05	0.065	0.0566	0.08	5.6	0.9	0.019	0.139	5.77	2.42
Hf	0.07-0.02	0.045	0.0986	0.45	0.049	0.59	0.24	0.0058	6.08	2.48
Hg	0.02-0.01	0.015	0.0449	0.02	0.049	0.029	0.00014	0.012	6.00	2.45
In	0.14-0.05	0.095	0.045	0.0061	0.009	0.0049	0.0415	0.017	5.91	2.50
Mn	292-22	157	123.3	292	0.014	739.7	91192	301.98	5.98	2.48
Ni	6.5-1	3.75	2.50	6.5	1.7	15	37.5	6.12	6.02	2.45
Pb	21.7-2.8	12.25	7.2	21.7	70	43.2	17.6	311	6.05	2.47
Rb	12.2-4.3	8.25	7.94	12.2	8.5	48.11	19.6	385.8	6.05	2.47
V	30-4	17	13.14	31	6	78.86	32.19	1036.5	6.10	2.45
Zn	75-4	39.3	2.271	7.8	1.8	13.63	5.56	30.96	6.02	2.46
Zr	7.8-0.6	39.3	2.271	7.8	1.8	13.63	5.56	30.96	6.02	2.46

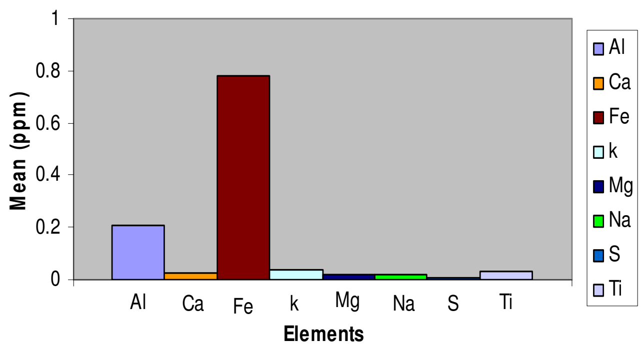

Fig 4: Histogram of Major Elements in Stream Sediments of the Study area

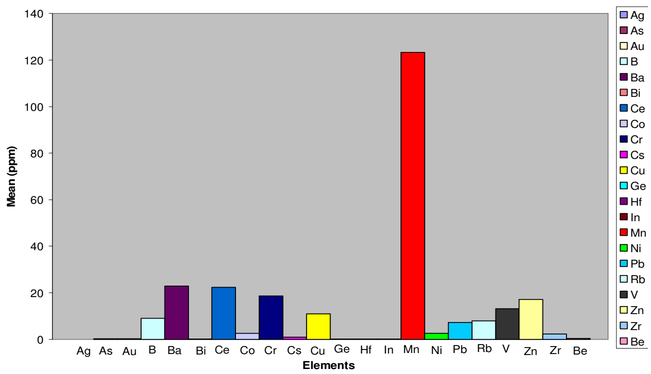

Fig 5: Histogram of Trace and Rare Earth Elements in Stream Sediment

The stream sediment data is presented in table.1 while the geochemical results of the elements analyzed are presented in table 2. The statistical tables for major trace and rare earth elements are shown in tables 3 and 4 respectively. The histograms of distribution of the major, trace and rare earth elements in the study area are also presented in Figs 4 and 5. Al. Ca, Fe, K, Mg, Na, S and Ti were the major elements analyzed in the stream sediments of Ara, Epe and Ijero Ekiti. The results showed that Al, Fe and Ca are the dominant major elements having averages of 0.21%, 0.78% and 0.077% respectively. A close examination of the results of analyses shows that there is no selective partitioning of the major elements in the stream sediments. Iron (Fe) has the highest proportion in the stream sediments, ranging between 1.86-0.22 % and an average value of 0.78%, indicating that a significant amount of the element might have originated from the weathering of silicate-bearing rocks rich in feldspar and mica. Fe has kurtosis and skewness of 5.46 and 2.41. The Fe content in the stream sediment of Ara is higher when compared to that of Epe and Ijero and the pattern of distribution varies from one location to the other in the study area. It is low in Epe (0.47%) compared to Ijero. It is likely that the parent rock from which the stream sediments originated is highly ferruginised or contained iron-bearing minerals. Aluminium (Al) is the next dominant element in the stream sediments ranging from 0.43-0.13% with an average value of 0.21, skewness and kurtosis value of 6.21 and 2.51 respectively (Table.2). It has the highest concentration in the stream sediments of Ijero when compared to that from Ara and Epe. This could be as a result of the enrichment of the underlying rocks in aluminosilicate minerals such as feldspars and mica.

The trace sediments analyzed include Ag, As, Au, B, Ba, Be, Ce, Co, Cr, Cs, Cu, Ce, Hf, Hg, In, Mn, Ni, Pb, Rb, V, Zn and Zr. However, the prominent trace elements detected in the stream sediments is Manganese (Mn). Manganese in the study area ranges from 292-22ppm with an average value of 123.29ppm, kurtosis and skewness value of 5.98 and 2.45 respectively (Tables 2 and 4). It has the highest concentration value in Ara-ijero with 292ppm and 241ppm respectively compared to the stream sediments from Ara and Epe. There is possibility of manganite enrichment in the underlying lithologies around Ara-ijero mostly from the pegmatites. Barium (Ba) is the second abundant trace elements detected with a range of 50-10ppm, an average value of 22.86ppm, kurtosis and skewness value of 6.00 and 2.45. The Barium content of the stream sediments from Ijero is higher compared to those of Ara and Epe. This revealed the high radioactive nature of the surrounding lithologies in the area. Cromium values in the sediment range between 63-4ppm with an average value of 18.6ppm. Cr has kurtosis and skewness value of 5.99 and 2.45 and has the highest concentration in the stream sediments from ijero. This could be attributed to the pegmatite rocks that are rich in chromium from which chromites may have been dispersed into the streams.

Celenium (Ce) value ranges betweem 33.8-6.95ppm, average value of 22.38ppm with kurtosis and skewness value of 6.00 and 2.45. The stream sediments from ijero recorded the highest value (46.5)ppm followed by the stream sediments from Epe. Zinc (Zn) value ranges between 74-4ppm with an average value of 17.14ppm, kurtosis and skewness value of 5.99 and 2.45. It has the highest concentration in Ijero (75ppm). Vanadium (V) has a range between 30-4ppm, average value of 13.14ppm, kurtosis and skewness value of 6.00 and 2.45 and has the highest concentration values of 31ppm and 30ppm from Ijero.

The rare earth elements determined comprise of Cd, Ga, La, P, Th, U, W, Y, Sn, Sr, Sc, Mo, Nb, Re, Se, Ta, Te, Tl and Ti. (Tables. 2 and 4). The most abundant rare earth element in stream sediments of the study area is phosphorous with a range of 420-40ppm, average value of 115.7, kurtosis and skewness values of 0.0014 and 2.45 repectively. The highest concentration was obtained from Ijero stream sediments. The high concentration of phosphorous may be a showing of economic concentration of phosphatic minerals probably the francolite-apatite series. The prominent minerals of Phosphorous (P) include apatite, monazite and torquise. Other rare earth elements include La, Th, U, Sr and Y with average values of 8.4ppm, 4.8ppm,1.5ppm, 3.07ppm and 2.2ppm respectively with average values of (15.3-3.3)ppm, (9.1-1.8)ppm, (3.22-0.51)ppm. (7.4-0.9)ppm and (3.77-1.07)ppm.

8. CONCLUSION

The result of geochemical investigation carried out on the stream sediments from Ara, Epe and Ijero Ekiti has revealed that the dominant major elements are Iron (Fe) and Aluminium (Al). The high percentage of these elements gives a clue to the probable origin of the parent rocks from which the stream sediments were formed; it is likely that magma of mixed origin must have been responsible for the varieties of minerals deposited. Most of the prominent elements in the result were derived from Ijero Ekiti this could be as a result of large pegmatite bodies found in the area which are known to host diverse mineral deposits. These elements include Al, Cr, Ce, Zn, V, Ba and P. Therefore, ijero area is a highly mineralized province compared to Ara and Epe. Geologic mapping of the area also showed that the oldest lithology in the study area is migmatite-gneiss which was intruded by granites and pegmatites. The pegmatites bodies are the youngest lithology.

9. RECOMMENDATION

Since the result of the preliminary studies indicate high values of Fe, Mn and P. in the study area, There is need to carry out detailed geochemical survey of the area to determine the environmental of deposition, the quantity and quality of these minerals (grade) and geophysical survey to determine the area extent and other hidden ore bodies likely to be associated with these deposits. It is also recommended that private investors and government should establish large scale mining industries for the exploration of these minerals. This will assist in economic and technological advancement of the study area and the nation at large.

AKNOWLEDGEMENT

I wish to acknowledge the effort of Olanitori Alex, for his assistance during the geological mapping and sample collection exercise for this work. I am also grateful to ACME Laboratories. East Vancouver, Canada for their technical assistance.

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