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The Background Concentrations of Major and Trace Elements in Rocks around Barkin Ladi and Environs, North Central Nigeria

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Abstract: *The study area falls within the Jos Plateau which is underlain by rocks of the Basement Complex and Younger Granite Complex, with some volcanics of quaternary/ Tertiary age. However the study area is partly within the Jos-Bukuru Complex and the Ropp Complex, and covers a total area extent of about 80 km^2 . The geological survey of the area was carried out which revealed ten (10) lithologic units differentiated based on the mode of formation, mineralogy and texture and were further classified into three categories based on age as follows: Crystalline Basement Rocks (Migmatite, Porphyritic Biotite granite and Older Granite), Younger Granite Complex (Biotite Microgranite, Rayfield gona Biotite Granite, Kassa Biotite Granite, Yelwa Pyroxene Granite, Vom Hornblende Biotite Granite, N'gell Biotite Granite) and Quaternary and Tertiary rocks composed of the Newer Basalts. Fresh rock samples representing each lithologic unit were collected, labelled appropriately with the geographical locations noted as well using the Global Positioning System (GPS). The samples were taken to the laboratory, crushed, pulverized and packaged. These were shipped to Acme Analytical laboratory in Vancouver, Canada for total whole rock geochemical analysis. The ICP-ES and ICP-MS options of analysis were carried out to achieve results for major oxides in percentage (%) and trace elements in parts per million (ppm) respectively. The results reveal that silica (SiO_2) is the most abundant major element while TiO_2 is the least abundant major compound in all the rock types. Generally, the Crystalline Basement rocks have the highest K_2O content of 5.09%, while, the Younger granite Complex contain the highest SiO_2 and Na_2O with 74.79% and 3.89% respectively. On the other hand, the Quaternary/Tertiary rock is rich in Al_2O_3, Fe_2O_3, CaO, Ti_2O and MnO contents with 13.86%, 12.25%, 8.54%, 8.93%, 2.33% and 1.16% respectively as compared with the other classes on rocks analysed. The trace element concentration reveal that Barium (Ba) concentration is as high as 567ppm in S5 (Rayfield gona Biotite Granite), Similarly, S8 (Newer Basalt) has the highest concentration of Cu, Ni, Sr and Co. Niobium is highest in S2 (N'gell Biotite Granite) and Ribidium concentration highest in S9(Kassa Biotite Granite). The main aim of this research is to establish the natural levels of these elements in the primary environment by providing a database on background concentrations of trace and major elements. This would make it possible to determine the anthropogenic influences on any specific site within the study area.*

Keywords: *Geology, Geochemical, Analysis, Background, Concentrations*

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I. Introduction

The Basement Complex rocks and the Younger Granites are the major rock types that underlie the Jos Plateau within which the study area is located. Jos Plateau is situated in a part of the Precambrian to Mid-Cambrian and Jurassic northern Nigerian crystalline shield [3]. The Basement Complex within this shield is of Precambrian to Mid-Cambrian age (600 ±150 Ma), whereas the Younger Granites, which are anorogenic and intrusive into the basement, are of Jurassic age (150 Ma). Also, recent works have shown that the Younger Granite activity of central Nigeria though dominant, was not the only magmatism affecting Nigeria in Jurrassic times, discoveries have revealed outcrops of Basalts which are of Jurassic age [5].

The study area forms part of the Jos-Bukuru Complex as well as the Ropp Complex which is located within the tin mineralization fields of the Jos Plateau. It is believed to have been accumulated as a result of the geology and secondary activities that took place in the past. The study area is characterized by the tropical climatic condition controlled by the wet and dry seasons. The former prevails between the months of April and October, while the latter starts in the month of November and ends in the month of March.

The soils found in the study area are dependent on the climate, geology, topography and time as a result of leaching from the parent rocks within and around the study area. The main preoccupations of the people in relation to the land are cultivation of grain crops like maize and guinea corn; vegetables like carrots, green beans, cabbages, green pepper and cucumber; tubers like sweet and irish potatoes, cocoyam, and yams, as well as mining activities which has been the main source of survival for the inhabitants.

The anthropogenic influences within the study area would be complex without a general background data on the elemental composition of the rocks. Such a database is essential to any systematic, accurate assessment of anthropogenic effects and natural causes of elevated or reduced levels of trace and major elements in an environment .Therefore, this piece of research is significant considering the fact that it will address the shortcomings in previous assessment where comparative data were not available. The results reported herein are a consistent data set available on background levels of trace and major elements within the study area.

Location Of The Study Area

The area of investigation is located in north-central Nigeria and lies within latitudes 9^{0} 32’28’’N and 9^{0}43’29’’N and longitudes 8^{0} 52’20’’E and 8^{0}56’12’’E (Fig. 1). It encompasses the Bisichi, Hiepang, Kassa and Barkin ladi communities and covers a total area extent of about 80 km^2 .

The study area is generally accessible through the Mararaban Jama’a - Mangu express road with some tarred feeder roads and footpaths linking the various communities (Fig. 1).

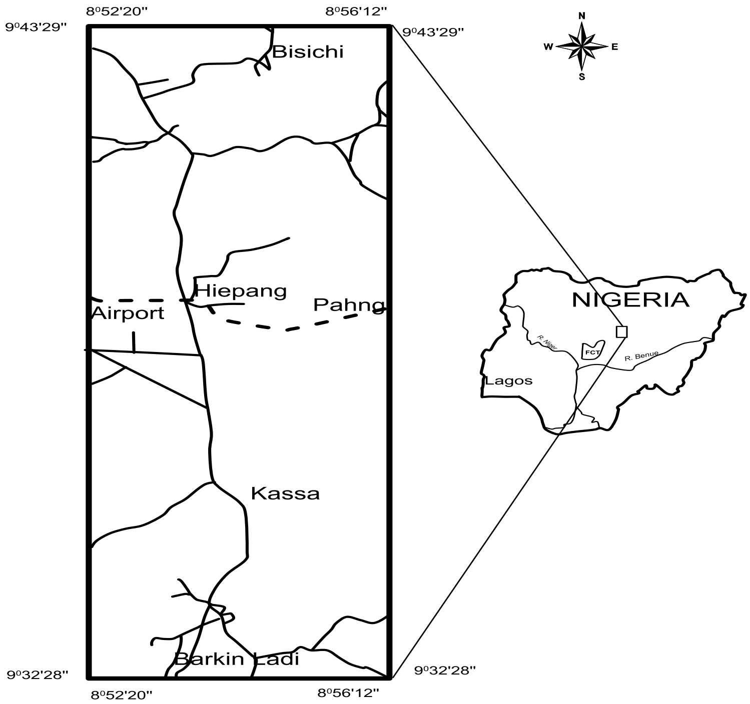

Fig.1. Location Map Of The Study Area

Geological Setting Of The Study Area

The study area lies partly within the Jos-Bukuru Complex and partly within the Ropp Complex and consists of ten (10) lithologic units differentiated on the basis of mode of formation, mineralogy and texture (Fig. 2) These rock units include the newer basalts, biotite microgranite, Rayfield gona biotite granite, Kassa Biotite granite, N’gell Biotite granite, Vom Hornblende Biotite granite, Yelwa Pyroxene granite, porphyritic biotite granite, older granite and the mignaties. Furthermore, the rock units can be classified based on age as follows:

A. Crystalline Basement Rocks
i. Migmatite
ii. Porphyritic Biotite Granite
iii. Older granite
B. Younger Granite Complex
i. Biotite Microgranite
ii. Rayfield gona Biotite Granite
iii. Kassa Biotite Granite
iv. Yelwa Pyroxene Granite
v. Vom Hornblende Biotite Granite
vi. N’gell Biotite Granite
C. Quaternary and Tertiary Rocks
i. Newer Basalts

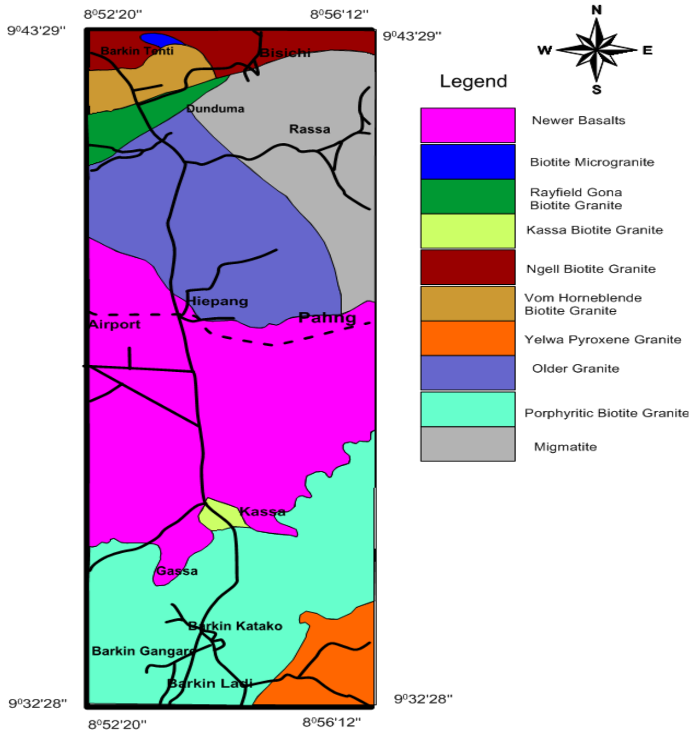

Fig. 2. Map Of The Study Area Showing The Different Lithologic Units

A. Crystalline Basement Rocks

i. Migmatite

This rock type occupies the north eastern segment of the study area, though most of the exposures are limited and the outcrops are of low relief. It has foliations of felsic and mafic minerals which are well developed and a medium grained texture.

ii. Porphyritic Biotite Granite

The porhyritic biotite granites form some of the most prominent features of the Basement rocks of the Jos Plateau. This rock unit occupies the southern, extreme south-western and parts of the south-eastern sections of the study area.

iii. Older Granite

The older granite occupies the north central and western parts of the study areas as shown on figure 2 above. It is generally low lying and obviously part of the Basement Complex suite. It was intruded during the Pan African orogenic cycle [2]. It is medium grained and generally felsic.

B. Younger Granite Complex

i. Biotite Microgranite

The biotite microgranite is found in the extreme north western part of the study area as a small intrusion (Fig. 2) within the N'gell Biotite Granite. The crystals/mineral grains are finer than the N'gell Biotite Granite with interlocking and randomly oriented mineral grains. It is pale greyish in colour.

ii. Rayfield Gona Biotite Granite

This is also found in the north-western portion of the area under review. The Rayfield-gona biotite granite has a low resistance to erosion. Jointing is close and irregular and the granite weathers to low outcrops of rounded white boulders and appears as hills only where buttressed by the more resistant earlier granites [1]. The texture of the Rayfield-gona granite is quite distinctive; it is fine to medium grained. The Rayfield-gona granite is characterized by a wealth of accessory minerals. It is distinguished as the granite richest in primary columbite and in addition contains thorite, cassiterite, and xenotime.

iii. Kassa Biotite Granite

This rock unit occupies a small portion in the central section of the research area and on the whole, only limited exposures are available owing to the cover of newer Basalts within the vicinity. It is a typically medium-grained biotite granite.

iv. Yelwa Pyroxene Granite

This outcrops in the extreme south eastern section of the study area and contributes to the rugged nature of the area. The rock is generally greenish in colour and porhyritic in texture. Obviously, hornblende and biotite are the typical mafic minerals making up this rock type in addition to quartz and feldspars.

v. Vom Hornblende Biotite Granite

This rock type is found in the north western part of the study area. It is generally felsic and has equigranular texture.

vi. N'gell Biotite Granite

This outcrops in the extreme northern, northwestern and north eastern sections of the study area (fig. 2), around Barkin Tenti and Bisichi areas. It is known to be intrusive into the Jos biotite-granite however it shows far greater textural variation than the Jos granite. It is a typical medium grained biotite-granite. The N'gell granite has been a major source of the alluvial deposits of tin and columbite within the area [1], where it has been established that the roof zones have been removed by erosion.

C. Tertiary and Quaternary Rocks

i. Newer Basalts

The newer basalts occupy the central, western and eastern sections of the research area. The basalts are believed to have erupted after the Plateau had achieved its present day topography and are themselves little affected by erosion [4]. This rock unit is a volcanic rock, dark grey in colour and very fine grained texture.

II. Method Of Study

Fresh rock samples representing each lithologic unit within the study area were collected using a sledge/ geological hammer and labelled appropriately. Likewise the coordinates of each point recorded using a Global Positioning system (GPS) (Table 1). These data were imputed into surfer 12 software worksheet and a post map layer generated, showing the distribution of the sample points within the study area. This layer was overlaid on the geological map of the study area as shown on Fig. 3 below.

Table 1: Rock Sample Coordinates

Sample No.	Longitude	Latitude	Elevation (m)	Lithology
S1	8.8812	9.7862	1271	Vom Hornblende Biotite Granite
S2	8.8929	9.7937	1278	N'gell Biotite Granite
S3	8.9001	9.7968	1277	N'gell Biotite Granite
S4	8.8751	9.7968	1282	Biotite Microgranite
S5	8.8120	9.7663	1277	Rayfield gona Biotite Granite
S6	8.9141	9.6981	1279	Migmatite
S7	8.8801	9.7538	1237	Older Granite
S8	8.8701	9.6693	1281	Newer Basalts
S9	8.8884	9.5992	1293	Kassa Biotite Granite
S10	8.8864	9.5321	1301	Porphyritic Biotite Granite
S11	8.9126	9.5313	1299	Yelwa Pyroxene Granite

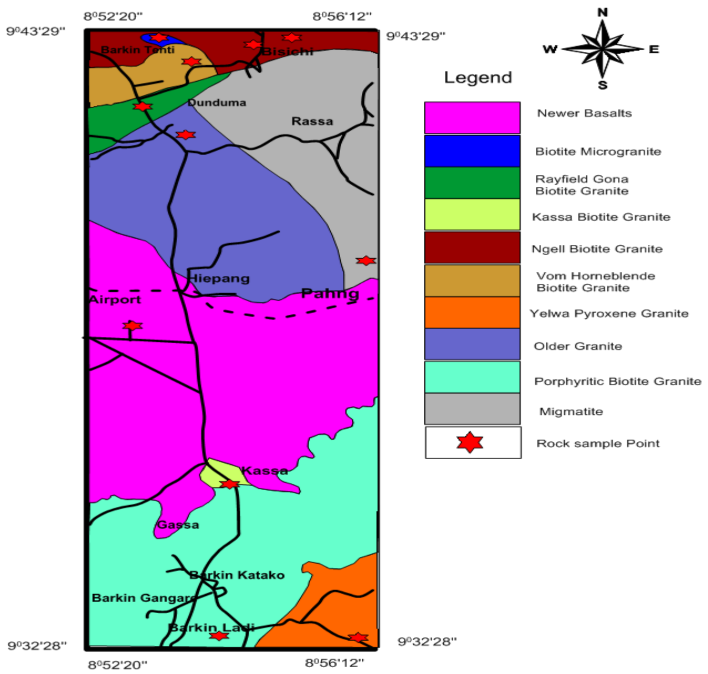

Fig. 3. Geological Map of the Study Area showing the Rock Sample Points

The rock samples were taken to the geochemistry laboratory of Nigerian Institute of Mining and Geosciences (NIMG) in Jos, where each sample was crushed, pulverized and packaged in sterilized clinical envelops. Same were appropriately labelled and shipped to ACME analytical Laboratory, Vancouver, Canada for Total whole rock geochemical analysis to determine the major, trace and rare earth elements using the Inductively Coupled Plasma Mass Spectrometry (ICP-MS) method.
Furthermore, Samples 4,3 & 5 where duplicated and used as quality control for the entire analyses. The results are displayed on Table 2 below.

Table 2: Major Element Concentration in Rock Samples

Major elements	S1 (%)	S2 (%)	S3 (%)	S4 (%)	S5 (%)	S6 (%)	S7 (%)	S8 (%)	S9 (%)	S10 (%)	S11 (%)
SiO_2	**77.20**	75.35	75.58	74.29	72.63	73.75	75.10	**45.38**	73.47	72.12	75.04
Al_2O_3	10.96	12.31	12.13	12.66	12.79	12.26	13.30	13.86	14.22	12.49	11.82
Fe_2O_3	1.85	2.10	2.12	2.32	2.91	2.79	1.47	12.25	1.73	4.10	2.77
MgO	0.02	0.02	0.02	0.04	0.03	0.03	0.18	8.54	0.03	0.06	0.06
CaO	0.86	0.49	0.58	0.68	1.07	1.03	0.45	8.93	0.35	0.82	0.49
Na_2O	3.37	4.03	3.74	3.99	3.83	3.64	3.23	2.30	4.33	3.60	3.95
K_2O	4.50	4.53	4.73	4.86	5.35	5.15	4.80	1.31	4.79	5.33	4.87
TiO_2	0.08	0.08	0.09	0.11	0.20	0.18	0.12	**2.33**	**0.02**	0.28	0.16
MnO	0.03	0.04	0.05	0.04	0.07	0.08	0.03	0.16	0.06	0.14	0.07
Total	98.87	98.95	99.04	98.99	98.88	98.91	98.68	95.06	99.00	98.94	99.23

Table 3: Average Concentration of Major elements in Rock Classes

Oxides (%)	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	MnO
Crystalline Basement Rocks	73.66	12.68	2.79	0.09	0.77	3.49	**5.09**	0.19	0.08
Younger Granite Complex	**74.79**	12.41	2.26	0.03	0.65	**3.89**	4.80	0.11	0.05
Quartenary and Tertiary Rocks	45.38	**13.86**	**12.25**	**8.54**	**8.93**	2.30	1.31	**2.33**	**1.16**

Table 4: Trace and Rare Earth Elements (REE) in Rock Samples

Trace and REE	S1 (ppm)	S2 (ppm)	S3 (ppm)	S4 (ppm)	S5 (ppm)	S6 (ppm)	S7 (ppm)	S8 (ppm)	S9 (ppm)	S10 (ppm)	S11 (ppm)
Ba	63	33	41	68	**567**	313	239	469	19	133	62
Cu	45.1	25.3	15.9	32.1	29.0	25.9	28.6	**74.4**	26.0	43.6	28.5
Ni	ND	ND	ND	ND	ND	ND	ND	**161**	ND	ND	ND
Sr	12.7	6.7	7.2	12.6	43.7	41.0	69.6	**671.3**	4.9	23.1	7.1
Co	0.7	1.3	0.9	1.2	1.2	1.6	1.4	**56.9**	1.1	2.1	1.3
Nb	225.6	**249.9**	229.1	219.7	129.6	108.3	15.3	56.9	43.2	77.5	148.0
Rb	248.7	593.2	516.0	552.4	229.8	238.2	219.7	37.7	**607.7**	142.9	210.2
Y	**182.6**	150.4	173.4	174.0	131.7	111.6	7.1	24.1	112.5	102.0	137.8

- REE-Rare Earth Elements
- ppm- parts per million

III. Discussion Of Results

Major Element concentration

Results of the geochemical analysis of the individual rock units showed that silica (SiO_2) is the most abundant compound in all the rock units with the highest percentage content in S9 which is Kassa Biotite Granite (77.20%) and lowest in S8 i.e the Newer Basalts (45.38%). However TiO_2 is the least abundant major compound with 0.02% seen in S9 (Kassa Biotite Granite) and highest percentage of 2.33% observed in S8 (Newer Basalts).

The ferromagnesian compounds (Fe_2O_3 and MgO) have varying abundances in the rock types. Fe_3O_2 is highest in S8 (newer basalt) with a value of 12.25% while the lowest percentage is present in S7 (older granite) with 1.47% content. Similarly, MgO is mostly abundant in the newer basalt (S8) with an 8.54% content and least abundant in S1, S2 and S3 i.e Vom hornblende biotite granite and N'gell biotite granite all containing 0.2% each.

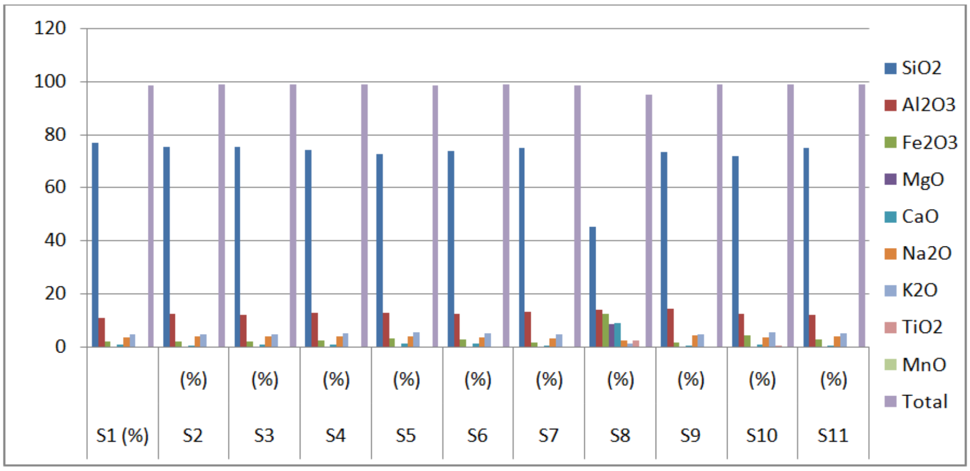

Figure 3: Major Element Concentration In Rocks Within The Study Area

Generally, the Crystalline Basement rocks have the highest K_2O content of 5.09% as compared with the Younger Granite suite and the Quaternary/Tertiary rocks. While, the Younger granite Complex contain the highest SiO_2 and Na_2O with 74.79% and 3.89% respectively as displayed on Fig. 4 below. On the other hand, the Quaternary/Tertiary rock is rich in Al_2O_3, Fe_2O_3, CaO, Ti_2O and MnO contents with 13.86%, 12.25%, 8.54%, 8.93%, 2.33% and 1.16% respectively as compared with the other classes on rocks analysed.

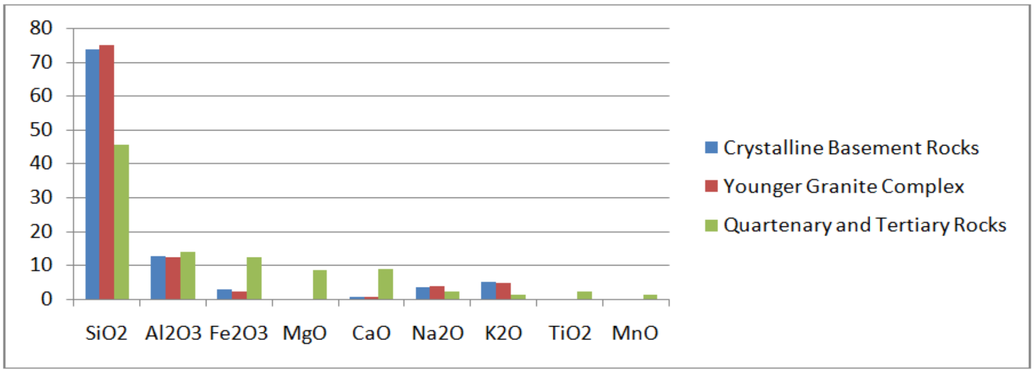

Figure 4. Average Concentration Of The Major Elements in Rock Classes Within The Study Area

Trace And Rare Earth Elements

The results of the trace and rare earth elements of the rocks revealed Barium (Ba) concentration as high as 567ppm in S5 (Rayfield gona biotite granite) which is radioactive. Barium is a naturally occurring component of minerals that are found in small but widely distributed amounts in the earth's crust, especially in igneous rock. Barium enters the environment naturally through the weathering of rocks and minerals. Similarly, S8 (newer basalt) has the highest concentration of Cu, Ni, Sr and Co. Niobium is highest in S2 (N'gell biotite granite) and Ribidium concentration highest in S9 which is Kassa biotite granite (Figure 5) below.

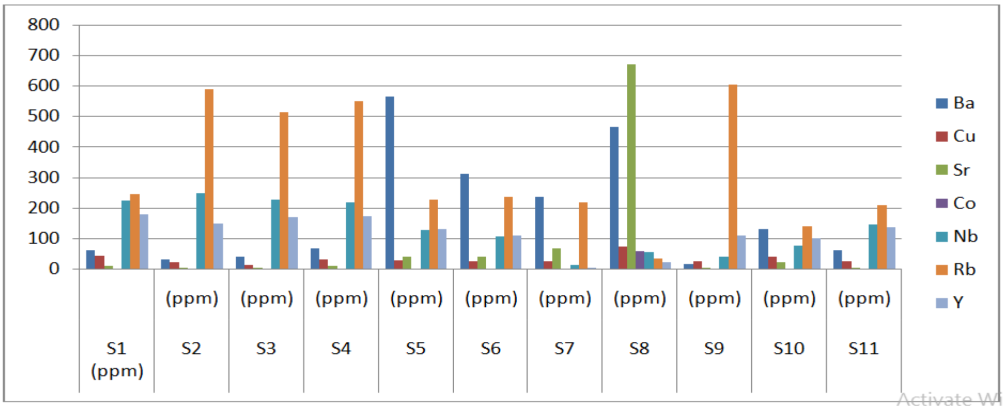

Figure 5: Trace And Rare Earth Element Concentration In The Rocks Within The Study Area

IV. Conclusion

The purpose of this study was to establish background concentrations for ten (10) rock units within Barkin ladi and environs. Parent materials were systematically sampled, prepared, and analyzed for major elements (SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, Na_2O, K_2O, TiO_2, MnO) and trace elements (Ba, Cu, Sr, Co, Nb, Rb, Y). Major and Trace element concentrations vary widely in the rock types with the Crystalline Basement rocks showing high concentration of SiO_2, K_2O, Al_2O3, Co and Rb. The Younger Granite complex revealed high concentrations of SiO_2, Al_2O3, Rb and Ba while the newer basalts displayed high concentrations of Fe_2O_3, MgO, CaO, Ba and Sr.

These data will certainly be a useful tool in the identification of areas suspected for trace element toxicity for human activities to thrive.

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