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Geological Settings and Geochemistry of Younger Granitic Rocks from Kuba Area, Ropp Complex, North-Central Nigeria

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Abstract
Kuba area is located in the Ropp complex of Younger Granite Province in northcentral Nigeria. Granitic rocks samples were studied geologically and geochemically using ICP-MS analysis for major oxides, trace and rare earth elements. The present study focuses on the determination of geological settings and geochemistry of granitic rocks in Kuba area. In the SiO_2 versus total alkali diagram (TAS) of granitic rocks for Kuba area, the granitic rocks predominantly plot in the alkaline field. Based on the A/CNK ratio (Al_2O_3/CaO+Na_2O+K_2O) which is >1, the younger granitic rocks are peraluminous in composition. The granitic rocks from Kuba area can be classified as A-type based on the classification of granites because of their alkalinity, anhydrous characteristic and presumed anorogenic tectonic settings. The normalized ratios of La_N/Yb_N for granite porphyry ranges from 27.11 to 28.33 and biotite granite ranges from 8.69 to 9.01. The normalized ratio of Ce_N/Yb_N for granite porphyry varies from 19.63 to 20.85 and biotite granite varies from 4.85 to 5.48. The normalized ratio La_N/Sm_N for granite porphyry ranges from 5.86 to 6.12 and biotite granite ranges from 2.88 to 2.91. The high values of the normalized ratios of La to Yb, Ce to Yb and La to Sm are evidence of high degree of fractionation, which show that the REE patterns are LREE enriched with the higher values recorded in the more fractionated granite porphyry than the biotite granite. The negative Eu anomalies in the granitic rocks show that high amount of plagioclase was removed from the felsic magma during fractional crystallization

Keywords: A-type, fractionation, enrichment, alkalinity and peraluminous

1. Introduction

Kuba area is located between latitudes $9^o 25'$ to $9^o 26'$ N and longitudes $8^o 56'$ to $8^o 57'$ E and occurs predominantly in Plateau State. The area is bounded to the North by Gana Ropp and west by Rarin Sho. Kuba area is accessible through Barkin Ladi-Mongu-Pankshin road while other minor roads and footpaths allow easy access to the study area. Kuba area occurs in the Rop Complex (Fig. 1), some of the central hills rise to more than 305 m above the Plateau surface and forms conspicuous landmarks. The drainage pattern in Kuba area is radial (Fig. 1) and essentially controlled by the distribution of the Younger granite outcrops. As most of the tin mineralization is associated with biotite granite, the alluvial tin deposits have been widely dispersed in the radial drainage system.

According to *Black (1971)*, Ropp Complex is the second largest tin producer in the Nigerian Younger Granite Province and extensive deposits of alluvial cassiterite have been exploited since 1920. Most of the cassiterite has been derived from greisen veins in the biotite granite, also present in some of the veins are finely disseminated sphalerite, pyrite and galena *(Ashano et al., 2006).* The Geology of the Jos Plateau has been exhaustively described by Macleod et al. (1971) and the history of tin mining in the area has been described by *Calvert (1977).* There is a very limited documentation on the geological settings and petrogenesis of the granitic rocks from Kuba area. The present study focuses on the geological settings and geochemistry of granitic rocks in Kuba area.

2. Methodology

During the fieldwork, exposed rocks in Kuba area within the Rop Complex were mapped and structural data (strike and dip) were collected. Fresh and representative rock samples were collected and were properly labelled. The representative rock samples were cut into the thin sections in the workshop of the Department of Geology and Mineral Sciences, University of Ilorin. Petrographic studies of these thin sections were carried out using the transmitted light petrological microscope.

The whole rock geochemical analyses comprising major oxides, trace elements and rare earth elements of five samples of the rocks were carried out at Acme Laboratory Ltd, Vancouver, Canada. All the rocks samples were pulverized at Geology Laboratory, University of Ilorin.The samples were analyzed for major oxides (SiO_2, TiO_2, Al_2O_3, Fe_2O_{3T}, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, Cr_2O_3, tot/C and tot/S); trace elements (Ag, As, Au, Ba, Be, Bi, Cd, Co, Cu, Cs, Ga, Hf, Hg, Mo, Nb, Pb, Rb, Sb, Se, Sn, Sr, Ta, Th, U, V, W, Zn, Zr and Y) and rare earth elements (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu) using a Lithium metaborate / tetraboratefusion and nitric acid digestion of 0.2g of each sample. To determine the geochemical characteristics of the granitic rocks, the samples were plotted on the SiO_2 versus total alkali diagram*(Le Maitre, 1989)* and the A/CNK ratio ($Al_2O_3/CaO+Na_2O+K_2O$) of the rocks were also computed.

2.1 Geological settings and Petrography

The younger granitic rock in Kuba area comprises of three lithological units and they include granite porphyry, biotite granite and microgranite as shown in Fig. 2*(Odewumi et al., 2015)*. The field characteristics and petrographic descriptions of the Younger granites in Kuba area are as follows:

Granite porphyry initiated the granitic cycle of the Rop Complex. Hornblende and biotite are the principal mafic minerals in the porphyry. The crystals are small but form clusters which attain a size of 2 mm. The groundmass is granophyric and there are occasional phenocrysts of plagioclase in addition to those of orthoclase. Granite porphyry shows dark green rounded xenoliths composed of fine-grained orthoclase and bluish green amphibole. Fayalite remnants have been noted in the cores of some of the amphiboles.

Biotitegranite occurs as smooth rounded hills reminiscent of some Older Granites and contacts with the Basement rocks are not exposed. The biotite granite is coarse-grained and equigranular with K-feldspar crystals up to 1 cm in diameter and clusters of biotite up to 1 cm. In thin sections, albite is more apparent than normal, as discrete crystals as well as patchy perthitic intergrowths. Biotite granite contain quartz (28-35 %), the crystals of which are usually clustered, or arranged in arcuate trains between the larger K-feldspars. Orthoclase and microcline microperthites are the common K-feldspars and biotites are generally pleochroic between deep brown and straw-yellow.

The microgranite is medium-grained in texture. The potash feldspars are turbid and have undergone a moderate degree of replacement by late albite which appears as irregular blebs within the perthites. Well-twinned laths of albite traverse the perthite and form a dentate pattern between the grains. In thin sections, a second generation of albite, appearing as abundant small, lath-like crystals appears to represent late stage albitization of parts of the intrusion. The microgranite comprises of auhedral crystals of quartz surrounded by matrix of biotite and plagioclase. Microcline shows poikilitic texture.

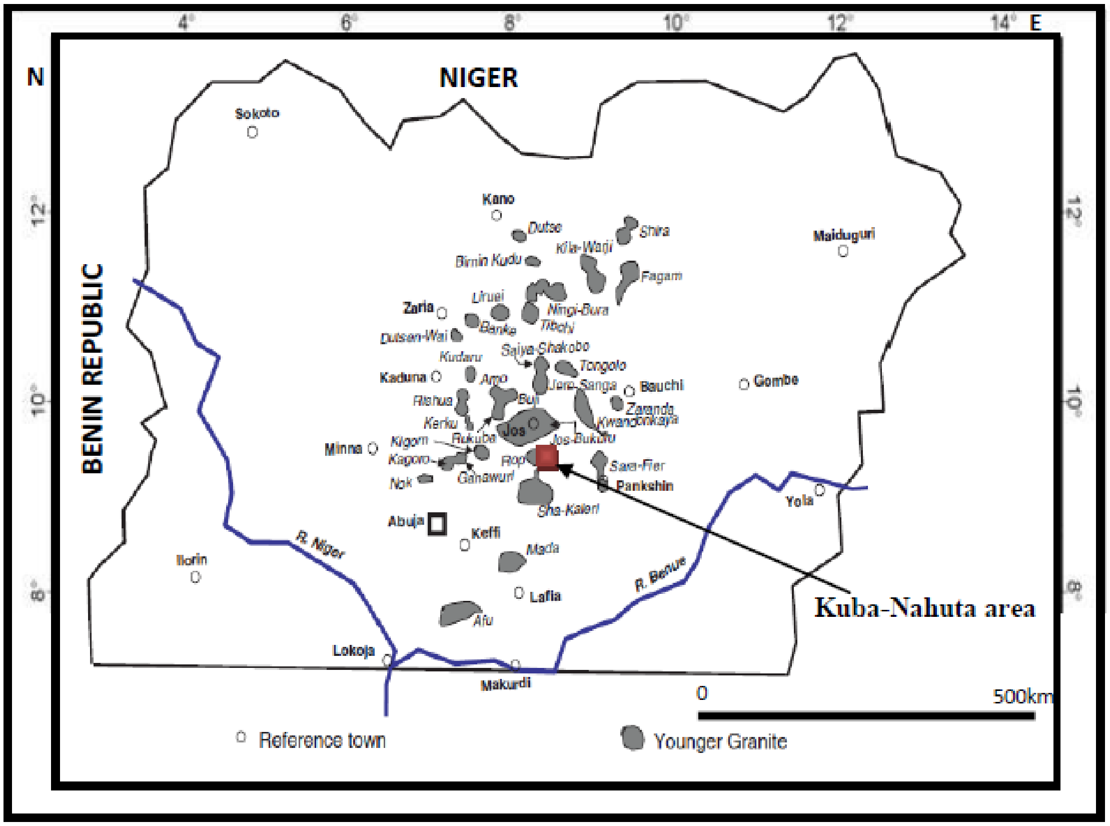

Fig. 1: *Location of the Younger Granites Complexes and Kuba-Nahuta area in northern Nigeria*

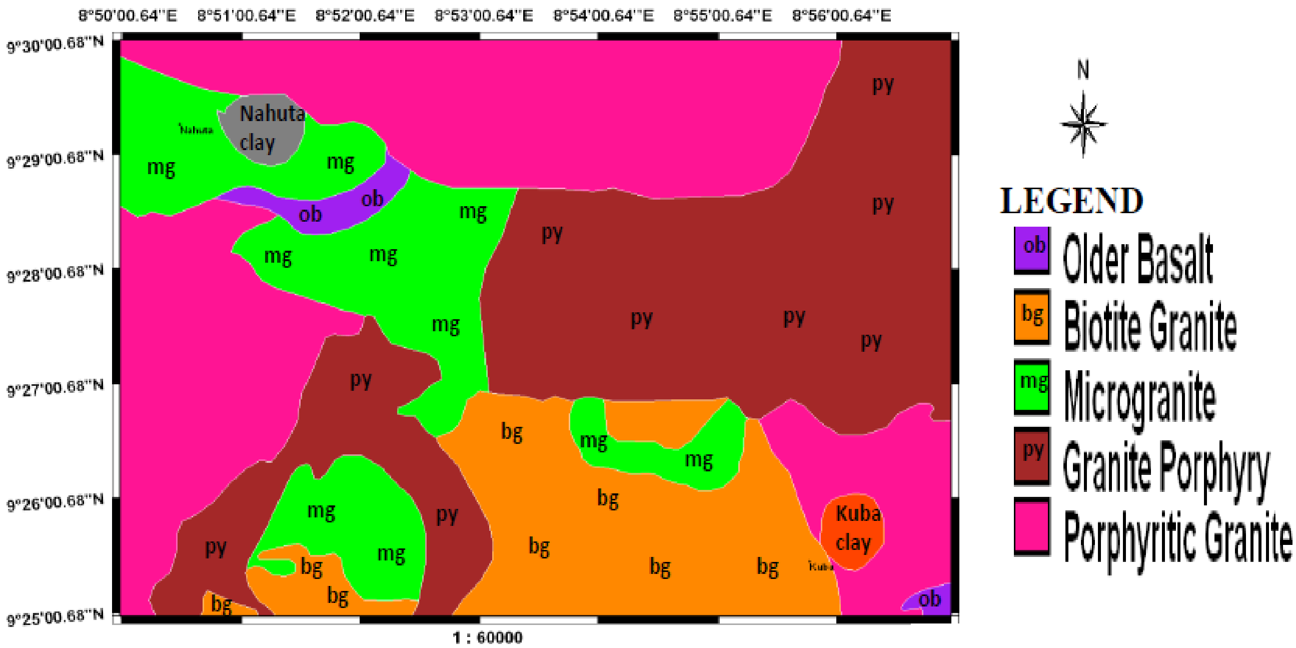

__Fig. 2:__ Geological map of Kuba-Nahuta area, Jos Plateau.

3. Results

3.1 Presentation of Results

The major oxide compositions of Younger Granites from Kuba area is presented in Table 1,rare earth elements composition of Younger Granites is presented in Table 2 and trace elements composition is presented in Table 3.SiO_2 content of the granite porphyry ranges from 67.69 to 70.56 wt% and is higher than SiO_2 compositions of biotite granite (54.09 -55.73wt%).$Fe_2O_{3(T)}$ content of granite porphyry is relatively lower than $Fe_2O_{3(T)}$ content of biotite granite (Table 1). The low concentrations of SiO_2 and K_2O in the biotite granite suggest crustal contamination.

Table 1: Major oxide compositions (wt%) of Younger Granites of Kuba area

Major oxides	KB 11 Granite Porphyry	KB 12 Granite Porphyry	KB 13 Biotite granite	KB 14 Biotite granite
SiO_2	70.56	67.69	54.09	55.73
Al_2O_3	14.37	15.66	15.86	15.58
Fe_2O_3	2.34	2.44	8.36	8.42
CaO	1.08	1.47	7.97	6.88

MgO	0.50	0.56	4.32	4.25
Na_2O	3.96	4.37	3.78	3.67
K_2O	5.1	5.96	0.71	0.73
MnO	0.03	0.06	0.18	0.19
TiO_2	0.35	0.38	1.54	1.58
P_2O_5	0.08	0.10	0.33	0.35
Cr_2O_3	0.002	0.002	0.03	0.03
LOI	0.88	0.81	2.10	2.14
SUM	99.37	99.64	99.43	99.55
TOT/C	0.06	0.06	0.2	0.2
TOT/S	<0.02	<0.02	<0.02	<0.02
A/CNK	1.42	1.33	1.27	1.38

Table 2: Rare earth element compositions (ppm) of Younger Granites from Kuba area

REE	**KB 11 Granite Porphyry**	**KB 12 Granite Porphyry**	**KB 13 Biotite granite**	**KB 14 Biotite granite**
La	65.7	51.9	25.2	24.40
Ce	119.7	94.3	37	39
Pr	12.54	9.72	5.15	5.29
Nd	43	32.2	22.4	23.6
Sm	6.63	5.46	5.35	5.23
Eu	0.91	0.79	2.06	2.34
Gd	4.55	3.97	7.43	6.99
Tb	0.55	0.49	0.97	0.86
Dy	2.9	2.8	5.75	5.38
Ho	0.61	0.47	1.2	1.06
Er	1.56	1.31	3.25	3.29
Tm	0.21	0.17	0.4	0.43
Yb	1.55	1.15	1.94	1.81
Lu	0.18	0.17	0.32	0.34
ΣREE	260.59	204.9	118.42	120.02
LREE	247.57	193.58	95.1	97.52
HREE	13.02	11.32	23.32	22.5
LREE/HREE	19.02	17.10	4.08	4.33

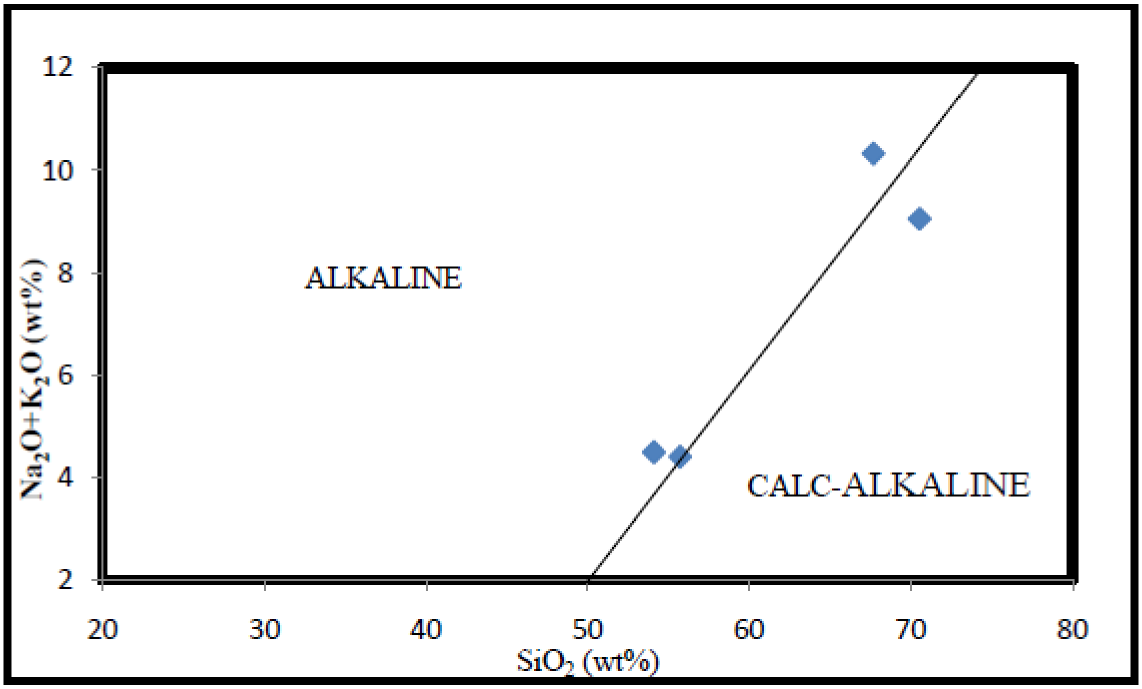

Fig. 3: Total alkali vs Silica oxide diagram for Granitic rocks of Kuba area *(Le Maitre, 1989)*

Table 3: Trace element compositions (ppm) of Younger Granites from Kuba area

Trace elements	**KB 11 Granite Porphyry**	**KB 12 Granite Porphyry**	**KB 13 Biotite granite**	**KB 14 Biotite granite**
Ba	631	834	276	328
Be	14	2	<1	2
Co	4	4.8	54.7	50.6
Cs	3.8	1.6	0.1	0.3
Ga	21.8	22.4	16	14.5
Hf	5.5	6.6	3.2	4.1
Nb	15	15	14.1	13.98
Rb	243.4	170	14.5	15.90
Sn	23	6	1	5
Sr	174.5	182.9	615.4	578.2
Ta	1.9	1.6	1.3	1.5
Th	59.9	26.4	2.4	2.8
U	12.1	5	0.7	1.1
V	12	18	65	54
W	1.6	1.1	<0.5	<0.5

Zr	193.3	250.2	133.3	122.8
Y	20.8	13.4	53.9	68.3
Mo	0.1	0.9	0.7	0.6
Cu	2.6	4.4	32.5	34.9
Pb	13.5	15.3	1	3
Zn	139	95	117	124
Ni	3.4	4.5	214.4	206.2
As	0.7	<0.5	<0.5	0.6
Cd	0.6	0.2	0.5	0.4
Sb	<0.1	<0.1	<0.1	<0.1
Bi	0.1	<0.1	<0.1	<0.1
Ag	<0.1	<0.1	<0.1	<0.1
Au	<0.5	0.6	<0.5	<0.5
Hg	<0.01	<0.01	<0.01	<0.01
Tl	0.6	0.1	<0.1	0.2
Se	<0.5	<0.5	<0.5	<0.5
Rb/Sr	1.40	0.93	0.024	0.028
Ba/Sr	3.62	4.56	0.45	0.57
Ba/Rb	2.59	4.91	19.03	20.63

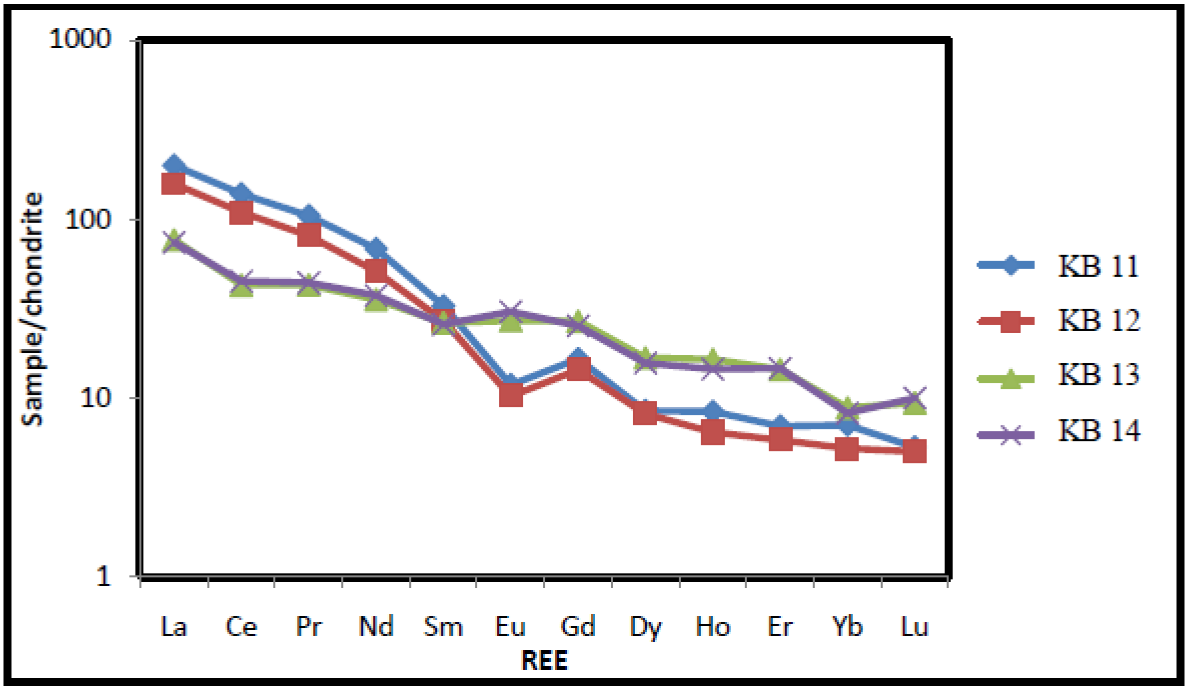

Fig. 4: Chondrite normalized plot of Younger Granites from Kuba area

3.2 Discussion of Results

In the SiO_2 versus total alkali diagram (TAS) of granitic rocks for Kuba area (Fig. 3) (Le Maitre, 1989), the granitic rocks predominantly plot in the alkaline field. Based on the A/CNK ratio ($Al_2O_3/CaO+Na_2O+K_2O$) which is >1 (Table 1), the younger granitic rocks are peraluminous in composition. The granitic rocks from Kuba area can be classified as A-type based on the classification of granites *(Collins et al, 1982)*. *Loiselle and Wones (1979)* called these granitoids A-type because of their alkalinity, anhydrous characteristic and presumed anorogenic tectonic settings. This is similar to the report of *Odewumi (2015)*on characteristics of the granitic rocksfrom Nahuta area.

The Younger Granites show similarities in the trace elements values of granite porphyry and biotite granite of Kuba area. The geochemical data indicates that the varying ratios of incompatible elements with values of Rb/Sr ratio (0.93 to 1.40) in the granite porphyry are higher than the value of Rb/Sr ratio (0.024 to 0.028) in the biotite granite. The values of Ba/Sr ratio (3.62 to

4.56) in granite porphyry are higher than the value of Ba/Sr ratio (0.45 to 0.57) in biotite granite. The values of Ba/Rb ratio (2.59 to 4.91) in granite porphyry are lower than the value of Ba/Rb ratio (19.03 to 20.63) in the biotite granite.

The geochemical data show large variation in the ratios of the incompatible elements with higher values of the ratios of Rb/Sr and Ba/Sr, and lower values of ratio of Ba/Rb in granite porphyry than the lower values of the ratios of Rb/Sr and Ba/Sr, and higher value of ratio of Ba/Rb in biotite granite. This indicates high fractionation which can be attained by magmatic differentiation. The lower ratio of Ba/Rb in granite porphyry than in the biotite granite further suggests fractionation trends *(Taylor, 1965; Rajesh, 2007; Obiora and Ukaegbu, 2010)*.The limited variation in the ratios of the incompatible elements of Rb/Sr, Ba/Sr and Ba/Rb for each group of the granites support partial melting and each granitic rock suite was affected by variable degree of partial melting. .

The chondrite-normalized REE plot for the Younger Granites of Kuba area is presented in Fig. 4. There is enrichment in the LREE relative to depletion in the HREE and the Younger Granites also show negative Eu anomaly which indicates fractionation. Granite porphyry exhibits similar REE distribution patterns with biotite granite (Fig. 4). The younger granites show high degree of fractionation with steep patterns, especially the LREE (La to Sm) fractionation relative to HREE (Gd to Lu) which exhibit varying degree of depletion in the area. The similarities in the REE patterns of the granite porphyry with the biotite granite suggest similar origin.

The granite porphyry is much more enriched with ΣREE values of 204.90ppm and 260.59ppm. while the biotite granite have ΣREE values of 118.42ppm and 120.02ppm respectively. All the granitic rocks have enrichment in the light rare-earth elements (LREE) relative to the heavy rare-earth elements (HREE). The enrichment factors ranges between 17.10 to 19.02 in granite porphyry and 4.08 to 4.33 in the biotite granite. The high level of enrichment in the LREE relative to the HREE in all the granitic rocks suggests high degree of fractionation. Light REE enrichment relative to the heavy REE has been reported in younger granite from Nahuta area by *Odewumi (2015)*.

The normalized ratio of La_N/Yb_N for granite porphyry ranges from 27.11 to 28.33 and biotite granite from 8.69 to 9.01. The normalized ratio of Ce_N/Yb_N for granite porphyry ranges from 19.63 to 20.85 and biotite granite from 4.85 to 5.48. The normalized ratio La_N/Sm_N for granite porphyry ranges from 5.86 to 6.12 and biotite granite from 2.88 to 2.91. The high values of the normalized ratios of La to Yb, Ce to Yb and La to Sm are evidence of high degree of fractionation, which show that the REE patterns are LREE enriched with the higher values recorded in the more fractionated granite porphyry than the biotite granite. The negative Eu anomalies in the granitic rocks (Fig. 4) show that high amount of plagioclase was removed from the felsic magma during fractional crystallization *(Rollinson, 1993)*

Conclusion

The granitic rocks from Kuba area can be classified as A-type granites because of their alkalinity, anhydrous characteristic and presumed anorogenic tectonic settings.

The geochemical data show large variation in the ratios of the incompatible elements with higher values of the ratios of Rb/Sr and Ba/Sr, and lower values of ratio of Ba/Rb in granite porphyry than the lower values of the ratios of Rb/Sr and Ba/Sr, and higher value of ratio of Ba/Rb in biotite granite. This indicates high fractionation which can be attained by magmatic differentiation. The lower ratio of Ba/Rb in granite porphyry than in the biotite granite further suggests fractionation trends.The limited variation in the ratios of the incompatible elements of Rb/Sr, Ba/Sr and Ba/Rb for each group of the granites support partial melting and each granitic rock suite was affected by variable degree of partial melting.

The high values of the normalized ratios of La to Yb, Ce to Yb and La to Sm are evidence of high degree of fractionation, which show that the REE patterns are LREE enriched with the higher values recorded in the more fractionated granite porphyry than the biotite granite.

References

Zhou, w.,Tsung,F. and Wang, Z.J.,2008. Application of Water Quality Control Charts to Spring Monitoring in Karst Terranes. *Environmental Geology 53(6): 1311-1321.*

Ashano E.C., Aduiku-Brown M.E. and Ayara E.U., 2006. Arsenic, lead and iron in soils and stream sediments from the Ropp Complex, North-Central Nigeria. *African Journal ofNatural Sciences 9: 51-57*

Black R., 1971. Southern Plateau. The Rop Complex. In M.S. Buchanan, W.N. Macloed andD.C. Turner (eds.). The Geology of the Jos Plateau. *Bulletin of the Geological Survey of Nigeria 2:107-119.*

Buchanan M.S., Macloed W.N., Turner D.C. and Wright E.P., 1971. The Geology of JosPlateau, Vol. 2. The Younger Granite Complexes. *Geological Survey Bulletin No. 32,106pp*

Calvert A.F., 1977. Nigeria and its tin fields. New York: Arno Press. 259pp.

Collins W.J., Beams S.D., White A.J.R. and Chappell B.W., 1982. Nature and origin of A-typegranites with reference to south eastern Australia. *Contributions to Mineralogy and Petrology 80: 189-200.*

Macleod W.N., Turner D.C. and Wright E.P., 1971. The Geology of the Jos Plateau, Vol.1, General Geology. *Bulletin of Geological Survey of Nigeria, 32, 119pp*

Le Maitre R.W., 1989. The chemical variation of some common igneous rocks. *Journal of Petrology 17: 376-389.*

Loiselle M.C. and Wones D.S., 1979. Characteristics and origin of anorogenic granites. *Geological Society of America, Abstracts with Programs, 11, p.468.*

Obiora S.C. and Ukaegbu V.U., 2010. Preliminary investigation of the petrogenesis and geotectonic setting of the Precambrian Basement Complex rocks around northcentral Nigeria using trace and rare-earth elements geochemistry. *Journal MiningGeology 46(2): 127-137*

Odewumi, S.C., 2015. Geology and geochemistry of granitic rocks from Nahuta area, Rop Complex, Jos Plateau, northcentral Nigeria. *Journal of Natural and Applied Sciences*4 (1): 61-75.

Odewumi, S.C., Adekeye, J.I.D. and Ojo, O.J., 2015. Trace and rare earth elements geochemistry of Kuba (Major porter) and Nahuta clays, Jos Plateau, northcentral Nigeria: Implications for Provenance. *Journal of mining and Geology*51 (1): 71-82.

Rajesh H.M., 2007. The petrogenetic characterization of intermediate and silicic charnockite in high grade terrains: a case study from southern India. *Contributions to Mineralogy and Petrology, 154: 591-606.*

Rollinson, H.R., 1993. Using geochemical data: Evaluation, Presentation and Interpretation.*Longman, UK*, 352p

Taylor S.R., 1965. The application of trace element data to problems in Petrology. *Physics andChemistry of the Earth 6:133-213.*