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Research Article

Major and Trace Element Geochemistry of Granites in Koji, Kogi State, Nigeria

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Abstract: Major and trace elements geochemistry of Koji granites were determined to deduce the petrogenesis of the rocks. Six granite rock samples were collected and analyzed for their major and trace elements using the Inductively Coupled Plasma Mass Spectrometer Methods. From the major element geochemistry, SiO_2 ranges from 69.34%-72.97% and hence suggests a felsic granite. The strong correlation between SiO_2 and CaO, MgO, Na_2O and Fe_2O_3, suggest that the primary mineral assemblage may have undergone significant changes during fractionation. The high K_2O content suggests the abundance of K-feldspar in the rock. From the trace element geochemistry, the High Field Strength Elements (HFSE) and the Large Ion Lithophile Elements (LILE) is consistent with values of the average granite and crust. The depletion of Sr suggests plagioclase fractionation. The plot of A/CNK against SiO_2 indicates a S-type granitoid and on the basis of alumina saturation, it suggests a peraluminous granite. Based on the A/CNK against SiO_2 plot and alumina saturation plot the geotectonic setting indicate volcanic arc syn-collisional granites.

Keywords: Fractionation, peraluminous, syn-collisional granites, volcanic arc

INTRODUCTION

Rocks of various parts of the Basement Complex have been studied by various researchers to explain their petrology, geochemistry, structural trends, mode of origin and age relationships (Rahaman, 1988; Ike, 1988; Oluyide, 1988; Rahaman and Ocan, 1988, Olarewaju, 1988; Elueze, 1987; Dada, 1999a; Obiora and Ukaegbu, 2010).

The study area is part of the Southwestern Nigerian Basement Complex (Fig. 1) that has responded to various tectonic events (Rahaman, 1988). The rocks also display stretching and mineral lineations which usually occur during asymmetric deformation of rock masses (Ebegbare, 2014).

The granitic rock around Koji, Kogi State Nigeria are extensive and appears as a dome shaped plutonic body and field relationships indicate evidence of deformation (Ebegbare, 2014). The Koji granite has elongated feldspar grains with pink colour and little bands of quartz and biotite. The feldspar grain are a clear evidence of the Pan-African Orogeny (Ebegbare, 2014).

This study has become necessary because according to Elueze and Bolarinwa (2004), proposing a single mode of origin for granites in the Nigeria Basement complex is difficult due to their variable composition from location to location. The aim of this study therefore is to propose the origin of the granites in this area particularly employing geochemical data.

MATERIALS AND METHODS

The study area is located between latitude 7° 05^{1}N to 8° 05^{1}N and longitude 5° 01^{1}E to 5° 08^{1}E in Kogi State, Nigeria.

Geological Field Mapping was undertaken to identify and collect the rocks in the study area. Six fresh rock samples of granite rock were collected and subsequently sent to Activation Laboratory, Ontario Canada for geochemical analyses using Induced couple Plasma Mass Spectrometer Method for the determination of major and trace elements of the rock samples.

RESULTS AND DISCUSSION

Major element results: Harkers variation diagrams are presented in Fig. 2 and 3 to establish geochemical evolution. MgO, Na_2O, P_2O_5, MnO, Fe_2O_3 and CaO exhibit a negative trend with SiO_2, whereas Al_2O_3, does not give any meaningful trend like the other oxides.

Generally, the strong correlation between SiO_2 and CaO, MgO, Na_2O and Fe_2O_3 suggest that the primary mineralogical assemblages of the rocks may have undergone significant changes during fractionation. Total alkaline content (Na_2O+K_2O) is high with K_2O content greater than Na_2O content in Koji granites and are similar to chemical composition of the Rapakivi granites (Emslie, 1973, Wilson, 1980).

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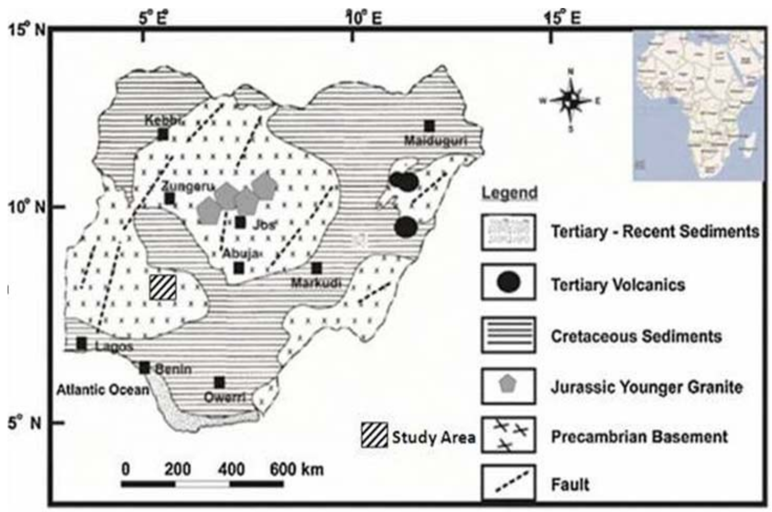

Fig. 1: Geologic map of Nigeria showing study area

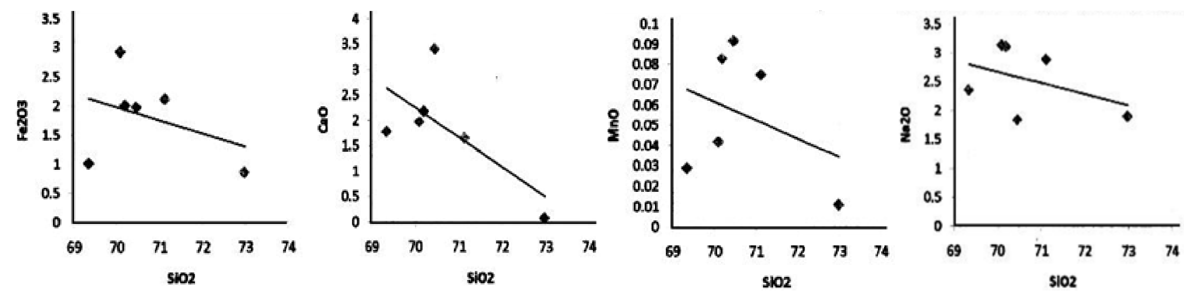

Fig. 2: Major element (Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O against SiO_2) Harkers plot for granite from the study area

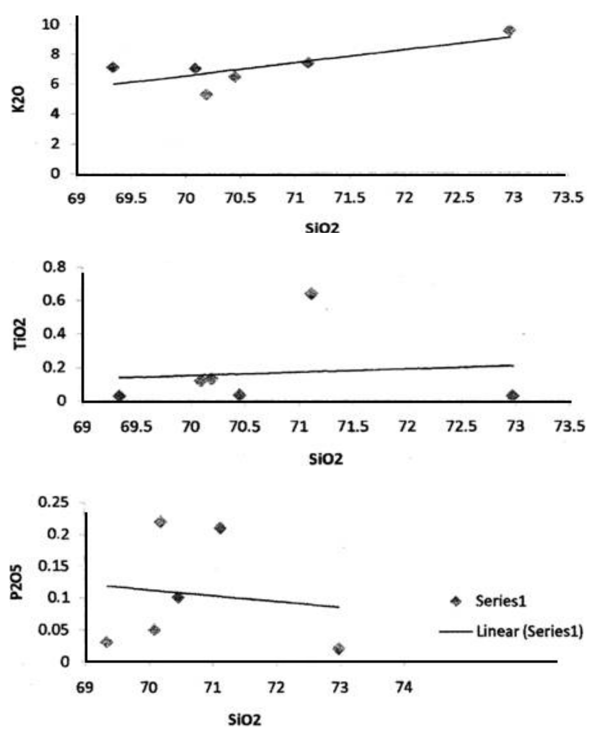

Fig. 3: Selected major element (K_2O, TiO, P_2O_2, against SiO_2) Harkers plot for granite from the study area

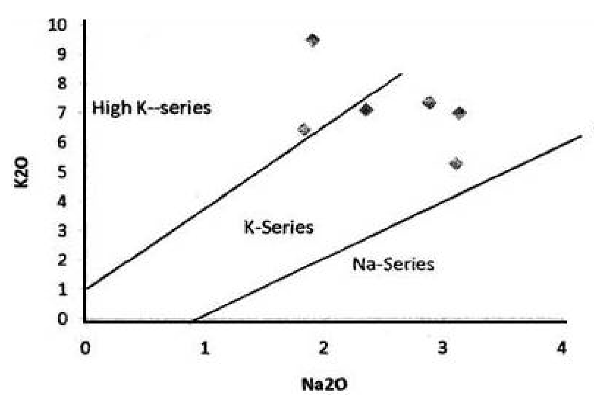

Fig. 4: Plot of K_2O vs Na_2O diagram subdiving the alkaline magma series into K-series, high K-series and Na series (after Middlemost, 1975)

A plot of K_2O against Na_2O suggests a magma rich in Potassium as shown in Fig. 4. High K_2O content suggest the preponderance of microcline in the granites (Olarewaju, 1988). Silica is most abundant ranging from 69.34-72.97% and hence suggests a felsic granite.

Trace element geochemistry: Trace elements are those which occur in very low concentrations in common rocks usually <0.1% by weight. Unlike major elements,

Table 1: Major element geochemistry

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
SiO_2	72.97	71.12	70.45	70.19	69.34	70.09
Al_2O_3	14.07	12.76	12.43	13.30	15.01	13.35
Fe_2O_3	0.86	2.12	1.98	2.01	1.02	2.93
MnO	0.011	0.075	0.092	0.083	0.029	0.042
MgO	0.02	0.74	0.69	0.68	0.43	0.22
CaO	0.09	1.66	3.41	2.19	1.78	1.98
Na_2O	1.91	2.89	1.84	3.11	2.36	3.14
K_2O	9.48	7.33	6.43	5.26	7.09	6.98
TiO_2	0.028	0.636	0.035	0.132	0.030	0.120
P_2O_5	0.02	0.21	0.10	0.22	0.03	0.05
LOI	0.10	0.25	0.31	1.22	1.46	0.10
TOTAL	99.55	99.79	98.78	98.39	98.58	100.002

Table 2: Trace element geochemistry

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Bc	2	7	6	6	4	2
Be	2	7	5	5	3	3
V	<5	<5	<5	<5	<5	<5
Cr	<20	<20	<20	<20	<20	<20
Co	<1	<1	<1	<1	<1	<1
Ni	<20	<20	<20	<20	<20	<20
Cu	<10	<10	<10	<10	<10	<10
Zn	<30	<30	<30	<30	<30	<30
Ga	23	21	22	23	21	24
Ge	3	2	3	3	2	3
As	<5	<5	<5	<5	<5	<5
Rb	768	763	759	769	752	768
Sr	19	18	19	17	20	19
Y	50	49	50	48	50	46
Zr	67	62	66	69	64	67
Nb	67	50	66	68	65	67
Mo	<2	<2	<2	<2	<2	<2
Ag	1.2	1.2	1.0	0.9	1.1	1.1
In	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Sn	3	5	2	3	4	4
Sb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cs	4.5	5.0	4.7	4.8	4.9	4.2
Ba	34	30	33	31	35	34
Hf	2.6	2.4	2.6	2.3	2.3	2.6
Ta	4.3	4.0	4.2	4.4	4.3	4.0
W	3	4	3	3	2	1
Ti	3.2	3	3.3	3.4	3.2	3.1
Pb	85	85	86	87	86	85
Bi	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Th	15.7	15	15.3	15.4	15.4	15.1
U	24.8	24.6	24	24.7	24.8	24.8

trace elements tend to concentrate in fewer minerals and are therefore more useful in formulating models for magmatic differentiation and in some cases, in predicting the source of a particular magma (Taylor, 1965) (Table 1).

Trace elements concentration of the granites in the study area is shown in Table 2. The values of the High Field Strength Elements (HFSE) (U, Be, Sn, Mo, W, Zr, Nb, Hf, Ta) and Large Ion Lithophile Elements (LILE) (Rb, Cs, Ba, Pb, Sr, Th) of the granitic rocks compared well with the values of average granite and crust. The enrichment of some of the HFSE like Nb, Zr and U in the granitic rocks suggest volatile concentrations during the evolution of granites (Onyeogocha, 1984). Of all the trace elements, Rb and Pb show abnormally high values compared to average granite and crust. This is consistent with the study of Elueze (1987).

Figure 5 shows some trace elements plotted against SiO_2 in the Harker's variation diagram. The plots show that strong correlations exist between SiO_2 and these elements. The granites are enriched in Rb, Pb, Zr, Ba, Sr and Y but depleted in Be, Hf, Ag, Mo, As, Co, Cr and V and this supports a felsic magma source. The elemental ratio of Koji granites are shown in Table 3.

Pearce *et al.* (1984) introduced a geochemical method to characterize the tectonic environment of granitic rocks and to demonstrate crystal fractionation of feldspar and biotite. Figure 6 shows the plot of Sr and Ba against Rb/Sr ratio. A very good negative trend is observed particularly in the Sr vs Rb/Sr diagram. The Rb/Sr ratio ranges from 37.6-45.2, The Ba/Sr ratios ranges from 1.666-1.823, Ba/Rb ratio ranges from 0.039-0.046. The limited variation of the incompatible element ratios of Rb/Sr , Ba/Sr and Ba/Rb of the granitic rocks suggest partial melting.

Table 3: Elemental Ratio of Koji granite

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Rb/Sr	40.4	42.2	39.9	45.2	37.6	40.42
Ba/Rb	0.044	0.039	0.043	0.040	0.046	0.044
Ba/Sr	1.789	1.666	1.736	1.823	1.75	1.789
A/CNK	1.225	1.436	1.064	1.259	1.336	1.103
A/NK	1.237	1.248	1.503	1.589	1.588	1.319

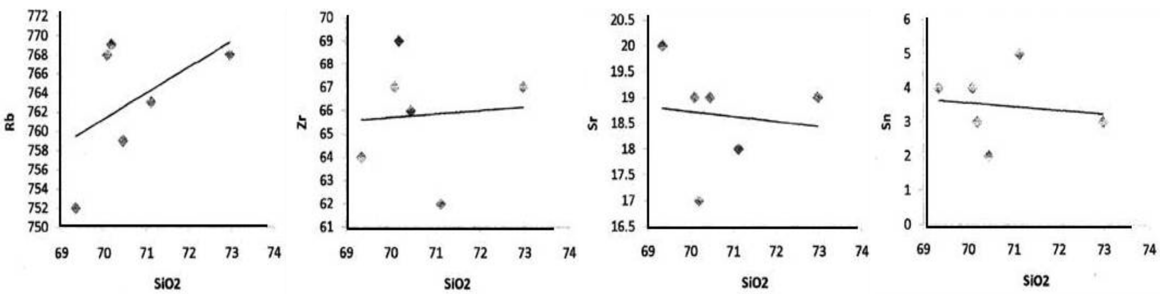

Fig. 5: Ba, Rb, Sr, Zr, U, Sn plotted against SiO_2

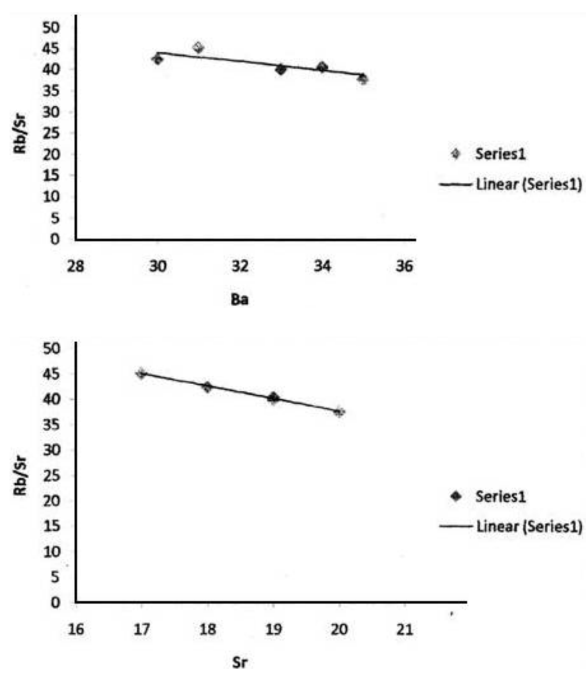

Fig. 6: Sr and Ba against Rb/Sr ratio

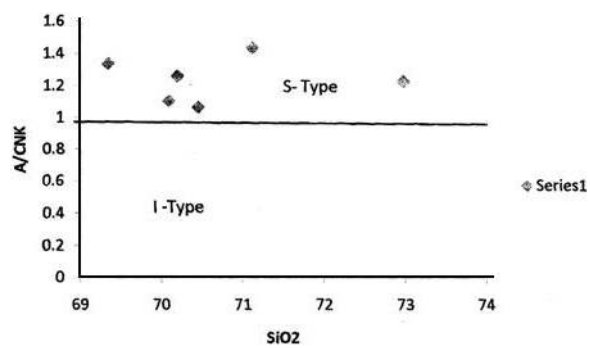

Fig. 7: A/CNK versus SiO_2

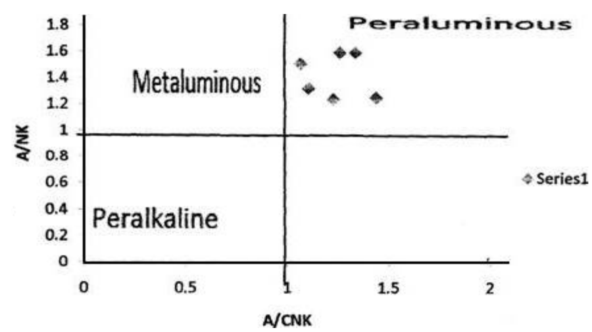

Fig. 8: A/NK versus A/CNK (after Maniar and Piccolo, 1989)

With Ba/Sr greater than 1 and Ba/Rb less than 1, fractional crystallization will result in decreasing Sr and Ba and enhancement of Rb. The depletion of Sr suggests plagioclase fractionation. The general trends of these trace elements also suggest that fractionation was dominated by alkali feldspar and biotite.

Figure 7 and 8 show plot of A/CNK against SiO_2 in which the granites plot as S- type granitoids while on the basis of alumina saturation as earlier proposed by White and Chappell (1988) the Al_2O_3/Na_2O+K_2O against $Al_2O_3/(CaO+Na_2O+K_2O)$ diagram indicates that the granitic rocks plot predominantly in the peraluminous field. The peraluminous granites are thought to be generated by partial melting of metasedimentary rocks as a result of thermal relaxation of the orogeny.

CONCLUSION

Geochemical characteristics show that the Koji granites correspond to the S-type granitoids because of their high SiO_2 composition (69.34-72.99), largely peraluminous relatively potassic and their geotectonic settings indicate volcanic arc and syn-collisional granites. High Rb/Sr ratios (40.4-37.6) and low Ba/Sr ratio (1.666-1.833) indicate high fractionation associated with magmatic differentiation. Furthermore, rare earth elements studies is recommended to gain more insight as to the petrogenesis of the granites.

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