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ARTICLE

Geology and Geochemistry of Iroko-Granites Southwestern Nigeria: Implication on Provenance

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ABSTRACT

The geology, geochemistry of Iroko-granites have been studied and reported in this paper. The study area has been described as of Archaean-Early Proterozoic terrain underlain by migmatite-gneiss-quartzite complex with supracustal rocks. Large number of granites which outcrops in Iroko-Ekiti represent a typical occurrence of granitoids sporadically distributed in the basement and are known to belong to the Older Granite suites, which are attributable to the Pan-African Orogeny (750± 150Ma). The rocks occur, mostly as flat and low lying within sparse vegetation. Structures common on and around the outcrops include quartz vein, veinlets, pegmatite dykes which trend North-south, discrete exfoliated surfaces and xenoliths of older rocks. This study reveals that the granites belong to calc-alkalic suites, demonstrate metaluminous nature, and exhibit characteristics of I-type granites. The granite is a distinctive type in that it is relatively highly potassic, has high FeO/(FeO + MgO) ratio, and high average Zr (299.75ppm) concentration with other high field strength elements. The trace elements study implicates pronounced fractional crystallization during evolution of the granites and thus petrogenetically discriminates as Syn-collision provenance.

1. Introduction

Iroko is about 37km NW of Ado-Ekiti, Southwestern Nigeria and lies within Latitudes 05^{o}05'^{E}, 05^{o}08'^{E} and Longitudes 007^{o}46'^{N}, 007^{o}55'^{N}, (Figure 1). This environment is prominent for mineralized pegmatites. Pegmatized environments play host to great diversities and concentrations of metal ores and various weathered by-products. This attracted the attention of researchers of diverse interests informing the publications of many researches on economic aspects of the area. However, very few researches have been reported on the surrounding and associated rocks in the area, particularly the granites. The area as part of the Pre-Cambrian basement complex of Southwestern Nigeria is underlain by crystalline rocks that were affected by the Pan- African orogeny. This orogeny, which was tectonothermal in nature, reworked the basement rocks severely and led to the emplacement of granitoids of different varieties dated 750±150Ma into several parts of Nigeria. The geology of the area has been well studied and reported as part of the southwestern Nigerian basement complex [1-7]. Grant [8] describe Ijero area which is a component of the southwestern Nigerian basement

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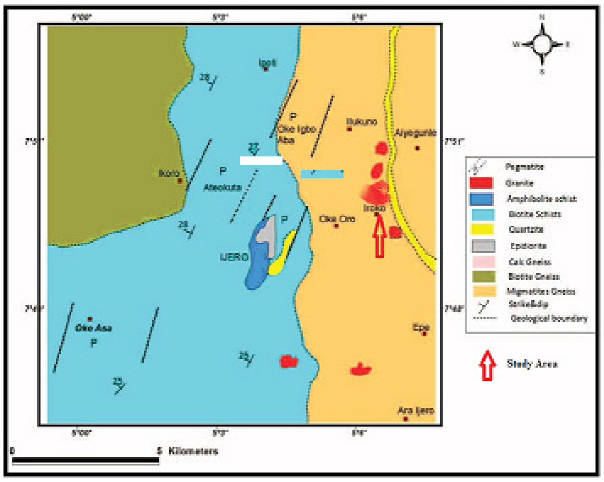
complex, and considered it an Archaean-Early Proterozoic terrain. Granites outcrop prominently and are of widespread exposure in the study area (Figure 1). This granites represent a typical occurrence of large number of granitoid bodies sporadically distributed in the basement and are known to belong to the Older Granite suites, which are attributable to the Pan-African Orogeny. There has been little or no previous detail study of the Iroko-granites in particular apart from in general context as one of the rocks within Ijero-Ekiti environment, hence this study: the geology and geochemistry of Iroko-granites implication on provenance.



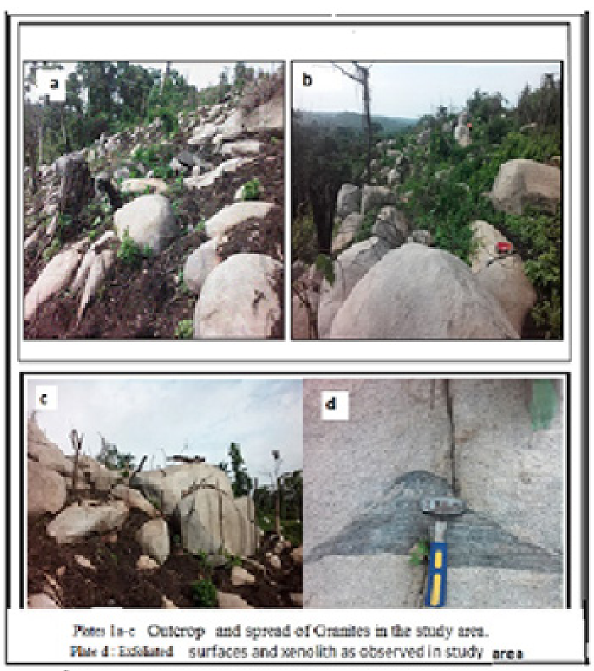


Figure 1. Map of Ijero showing the Iroko-Ekiti (modified after Okunlola and Akinola. 2010) and below Plate 1ab and c

2. Geological Setting

The geology of Iroko - Ekiti as part of Ijero and its environs has been well studied and reported in literature [1,3,4,8-11]. This study area has been considered an extension of Ilesha Schist belt based on similarity of rock types [12]. The area has been described as of Archaean - Early Proterozoic terrain underlain by migmatite-gneiss-quartzite complex with supracustal rocks [13,14]. Other prominent rocks are the amphibolites, the calc-gneiss, the granites and the mineralized pegmatites, which have been worked severally for both metallic, non-metallic minerals and weathered by-products. Locally, Iroko area is composed of highly weathered migmatites, the granites, veins and a few pegmatites variously intruding into the pre-existing basement rocks. In the area, the granites outcrops in form of batholiths, round to sub-rounded outcrops, and oblong to spheroidal bodies in places covering an extensive area of more than 4 kilometers (Plate 1 a-c). The rocks occur, mostly as flat and low lying within sparse vegetation. Structures common on and around the outcrops include quartz vein, veinlets, pegmatite dykes which trend North-south, discrete exfoliated surfaces and xenoliths of older rocks (Plate 1d).

3. Materials and Methods

Since the principal focus of this research is to study the occurrence of the granites, and determine their petrochemical characteristics, 20 representative samples were collected at random but attention was given to texture and colour variations during the mapping exercise. The samples were crushed to sizes required for petrography and geochemical analyses. Selected 10samples were prepared for thin sectioning and photomicrographs, and those selected for geochemical analysis were crushed and milled at the Laboratory of the Department of Geology Ekiti State University, Ado-Ekiti, Nigeria. The ten representative samples were sent to the Activation Laboratories, Canada for whole rock analysis. For this research, code 4B package was used, where Lithium metaborate/tetraborate fusion ICP method was applied. The samples were analyzed by Perking-Elmer-Sciex ELAN6100. The fusion ICP has a detection limit of 0.01 percent for most oxides except MnO and TiO_2 (0.001). The instrument is programmed for regularly recalibration to prevent error.

4. Petrography

In the slides of the Iroko-granites, feldspar (microcline), abundance of quartz, biotite and opaque minerals were studied. Microcline and quartz occur as large crystals,

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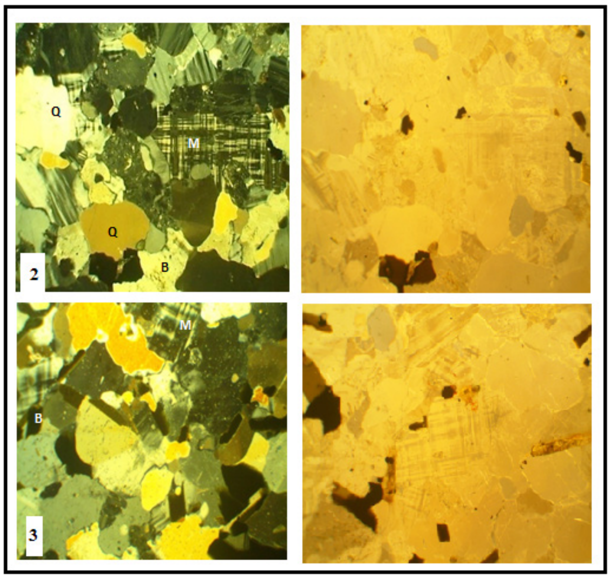
biotite content is very low compared to quartz, and feldspar which occur as disoriented masses on the slides. Plagioclase occurs in large crystals in some of the samples. Other minor components include ferromagnesian minerals like hornblende, magnetite. Quartz and the feldspars alone constitute up to about 70% volume of the rock as observed in thin sections while others are opaque minerals as shown in (Plates 2&3) this explains the grey to white appearance of the rocks.



Plates 2 and 3. Showing photomicrographs of Iroko-granites in Crossed and polarized lights (B-Biotite, Q-quartz, M-Microcline)

5. Results and Discussion

The geochemical data for the major element oxides (wt. %), trace and rare earth elements (ppm) are presented in Table 1a and 1c. Table 1b compares the current study with other published works. A careful study of Table 1a reveals an average of high SiO_2 (71.5), high K_2O (6.13) concentrations with moderate Al_2O_3 (13.5), Fe_2O_3 (2.7), Na_2O (2.7) and low CaO (1.5) values. Other oxides such as MgO (0.42), TiO_2 (0.32). P_2O_5 (0.12), and MnO (0.03) are expectedly low. The average total alkali concentration is 8.78% (8.58-9.16%) and K_2O/Na_2O ratios on the average are 2.23, these parameters are higher compared with most other published granites (Table 1b). The high ratio reflects the abundance of K-bearing silicate minerals in the rock. The plot of Na_2O+K_2O vs SiO_2, (after [15], Figure 2a), established the rock as granites with all the data plotting within the granite field, and also classified as of sub-alkaline magmatic series rather than alkaline type, boundary line between the series defined by [16]. Again on the normative mineral compositions of the rock samples plotted on anorthoclase-albite-anorthite Feldspar triangle [17], the data classify the rock as granites (Figure 2b). In the AFM ternary diagram (Figure 3a), Iroko-granites classify as of calc-alkaline series rather than of tholeiite series [18], while it plots in the "Alkali-calcic" field in Na_2O + K_2O - CaO vs SiO_2 diagram (Figure 3b) [19]. A thorough observation of the data shows the rock as having high K_2O (av 6.13) which makes the data discriminate the rock as high-K_2O composition on K_2O vs Si_2O (Figure 3c).

Table 1a. Major Oxides Composition (wt%) of Iroko-granites

S/N	G16	G17	G18	G19	G20	G21	G22	G23	G24	G25	Ave.
SiO_2	71.58	71.92	72.26	71.77	71.28	71.32	71.35	71.26	71.16	71.37	71.53
Al_2O_3	13.41	13.39	13.37	13.67	13.97	13.62	13.26	13.25	13.23	13.32	13.45
Fe_2O_3	2.72	2.67	2.62	2.67	2.72	2.74	2.75	2.68	2.60	2.66	2.68
MnO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
MgO	0.45	0.44	0.43	0.43	0.43	0.40	0.37	0.385	0.40	0.43	0.42
CaO	1.52	1.475	1.43	1.46	1.48	1.455	1.43	1.43	1.43	1.475	1.46
Na_2O	2.64	2.63	2.62	2.70	2.78	2.735	2.69	2.605	2.52	2.58	2.65
K_2O	5.94	6.005	6.07	6.225	6.38	6.24	6.1	6.14	6.18	6.06	6.13
TiO_2	0.33	0.33	0.33	0.33	0.33	0.33	0.32	0.32	0.31	0.32	0.33
P_2O_5	0.06	0.09	0.12	0.105	0.09	0.075	0.06	0.06	0.06	0.06	0.08
Total	99.33	99.63	99.93	100.0	100.1	99.48	98.86	98.68	98.5	98.92	99.34
LOI	0.62	0.63	0.64	0.63	0.62	0.55	0.48	0.53	0.58	0.6	0.59
K/N	2.25	2.28	2.32	2.31	2.30	2.29	2.27	2.36	2.45	2.35	2.32
N+K	8.58	8.64	8.69	8.93	9.16	9.00	8.79	8.75	8.70	8.64	8.78
A/ CNK	1.33	1.32	1.32	1.32	1.31	1.31	1.30	1.30	1.31	1.32	1.31
NK/A	0.64	0.65	0.65	0.65	0.66	0.66	0.66	0.66	0.66	0.65	0.65

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Table 1b. Iroko-granites data compared with other published Granites

Oxides	IRG	GGG	IPG	SMG	GEG	KAG	Finland	I-type	S-Type	A-type
SiO_2	71.53	68.9	72.78	67.86	76.69	65.42	72.45	72.9	71.58	73.47
Al_2O_3	13.45	14.9	14.8	14.9	12.62	15.9	13.61	13.48	13.83	12.88
$Fe_2O_{3\,(T)}$	2.68	3.6	1.89	3.97	1.3	7.24	3.3	3.97	5.62	5.07
MnO	0.04	0.07	0.03	0.06	0.02	0.136	0.06	0.05	0.05	0.06
MgO	0.42	0.91	0.72	0.68	0.06	2.65	0.28	0.66	1.02	0.3
CaO	1.46	1.99	1.48	2.15	0.3	1.69	1.47	1.63	1.74	1.06
Na_2O	2.65	3.97	3.01	3.32	3.3	2.69	2.66	3.27	2.57	3.5
K_2O	6.13	4.48	4.46	5.72	5.05	3.43	5.48	4.42	4.33	4.62
TiO_2	0.33	0.4	0.28	0.61	0.06	0.84	34	0.3	0.42	0.3
P_2O_5	0.08	0.22	0.15	0.19	0.01	0.21	0.06	0.09	0.14	0.07
LOI	0.59	0.63	0.3	-	1.53	-	0.28	0.3	0.13	0.12
M/F+M	0.14	0.2	0.28	0.85	0.96	0.73	0.08	0.14	0.15	0.06
K/N	2.31	1.13	1.48	1.72289	1.5303	1.27509	2.06	1.4	1.7	1.32
K+N	8.78	8.45	7.47	9.04	8.35	6.12	8.14	7.69	6.9	8.12

Sources: IRG-Current Study, GGG-Guguruji Granite (OlaOlorun, 2012), IPG-Ipetu Granite(Oyinloye, 2000), SMG-Saminaka Granite (Olarewaju and Rahaman, 1982), GEG-Glen Eden Granites SW, Australia (Somarin, 2011)

Table 1c. Trace Elements Composition (ppm) of Iroko-granites

S/N	G16	G17	G18	G19	G20	G21	**G22**	**G23**	**G24**	**G25**	**Ave.**
Sc	4	3.5	3	3.5	4	3.5	3	3	3	3.5	3.4
Be	4	4	4	4	4	4	4	4	4	4	4
V	17	17	17	17	17	16	15	15.5	16	16.5	16.4
Ba	676	686	696	699.5	703	680	657	649.5	642	659	674.8
Sr	162	160	158	163	168	165	162	165	168	165	163.6
Y	29	30.5	32	31.5	31	31	31	30.5	30	29.5	30.6
Zr	284	291.5	299	303.5	308	300.5	293	288.5	284	284	293.6
Cr	20	20	20	20	20	20	20	20	20	20	20
Co	19	20.5	22	18	14	17	20	18.5	17	18	18.4
Ni	20	20	20	20	20	20	20	20	20	20	20
Cu	10	10	10	10	10	10	10	10	10	10	10
Zn	50	45	40	45	50	50	50	45	40	45	46
Ga	19	19	19	19.5	20	20	20	19.5	19	19	19.4
Rb	355	361.5	368	373.5	379	383.5	388	373.5	359	357	369.8
Nb	18	17.5	17	18	19	18.5	18	18.5	19	18.5	18.2
Cs	3.5	3.15	2.8	3.1	3.4	3.1	2.8	2.6	2.4	2.95	2.98
La	213	215	217	217	217	218.5	220	216	212	212.5	215.8
Ce	390	392	394	394.5	395	400.5	406	394.5	383	386.5	393.6
Pr	36.7	37.25	37.8	37.5	37.2	37.55	37.9	37	36.1	36.4	37.14
Nd	113	113	113	113.5	114	115.5	117	113	109	111	113.2
Sm	16.1	16.1	16.1	16.35	16.6	17.05	17.5	16.8	16.1	16.1	16.48
Eu	1.27	1.21	1.15	1.22	1.29	1.27	1.25	1.22	1.19	1.23	1.23
Gd	10	9.9	9.8	10.05	10.3	10.5	10.7	10.55	10.4	10.2	10.24
Tb	1.4	1.4	1.4	1.4	1.4	1.45	1.5	1.5	1.5	1.45	1.44
Dy	6.4	6.5	6.6	6.75	6.9	6.95	7.00	6.75	6.5	6.45	6.68
Ho	1.1	1.1	1.1	1.1	1.1	1.15	1.2	1.15	1.1	1.1	1.12
Er	3.1	3.05	3	3.1	3.2	3.2	3.2	3.2	3.2	3.15	3.14
Tm	0.42	0.41	0.4	0.42	0.44	0.435	0.43	0.425	0.42	0.42	0.422
Yb	2.6	2.6	2.6	2.7	2.8	2.85	2.9	2.8	2.7	2.65	2.72
Lu	0.41	0.415	0.42	0.415	0.41	0.42	0.43	0.42	0.41	0.41	0.416
Hf	8.6	8.55	8.5	8.8	9.1	9.05	9	9.45	9.9	9.25	9.02
Ta	2	1.95	1.9	1.95	2	1.95	1.9	2	2.1	2.05	1.98
W	163	174	185	154.5	124	151	178	169.5	161	162	162.2
Tl	2.6	2.4	2.2	2.15	2.1	2.1	2.1	2	1.9	2.25	2.18
Pb	43	42.5	42	42.5	43	44.5	46	44.5	43	43	43.4
Th	142	143	144	149.5	155	154.5	154	151	148	145	148.6
U	13.8	12.2	10.6	11.45	12.3	12.05	11.8	11.9	12	12.9	12.1

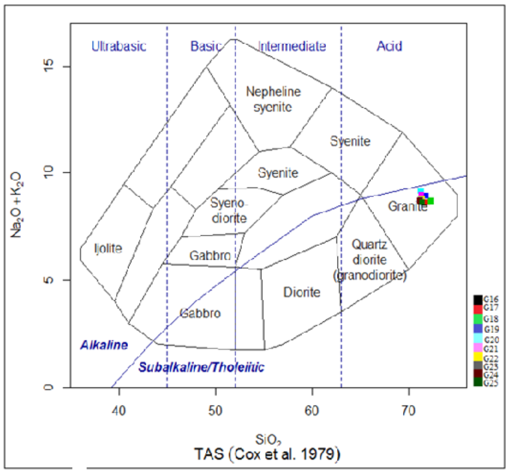

Fig. 2 Showing TAS diagram of Cox et al. (1979), classifying the data as of granites of sub-alkaline magmatic series as against alkaline type, the boundary line between the series defined by Miyashiro (1978).

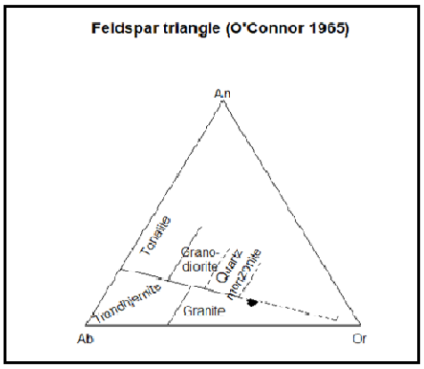

Fig. 2b: Plot of normative mineral compositions of the rock samples

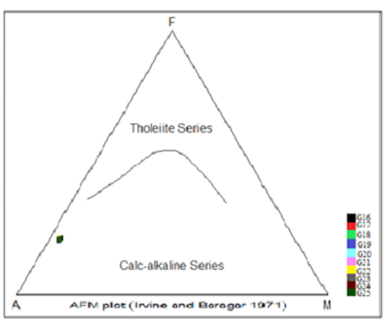

Fig. 3a Ternary diagram for Iroko-granites (after Irvine and Baragar, 1971)

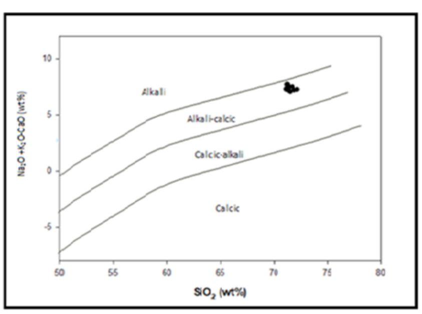

Fig. 3b: Plot of $Na_2O + K_2O - CaO$ vs SiO_2 diagram (After Frost et al., 2001)

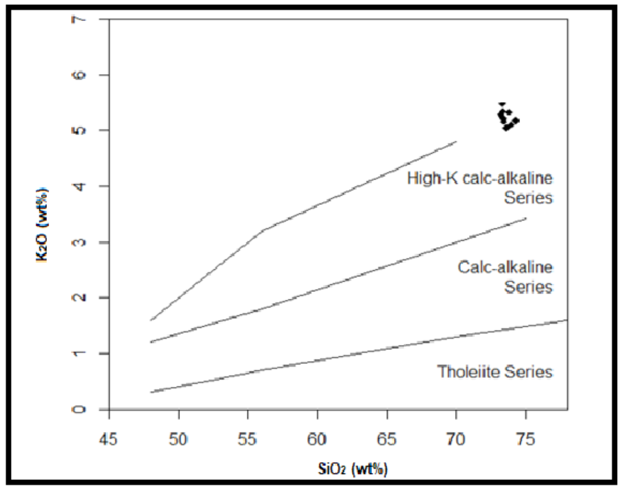

Figure 3c. Iroko-granites discriminate as of High-K calc-alkaline Series

Furthermore, using the molecular ratio of alumina to alkalis after Shand (1943) (Figure 4), i.e. plotting Al_2O_3/ (Na_2O + K_2O) A/NK vs Al_2O_3 / (CaO +Na_2O + K_2O) A/CNK, Iroko-granites classify as I-type granite and of metaluminous affinity. Literature reveals that I-type granites are typical of subduction zones and also occur in continental collisional belts. The granite is a distinctive type in that it is relatively highly potassic, has high FeO/(FeO + MgO) ratio, and high average Zr (299.75ppm) concentration with other high field strength elements. Figure 5 Shows the Harker diagrams of correlation between SiO_2 and some oxides such as Al_2O_3, TiO_2, Fe_2O_3, and K_2O.The significant correlation between compatible and sometimes incomparable elements or oxides with themselves is often interpreted as being of a single magma source or due to mineral fractionation. The correlation between SiO_2 vs Al_2O_3, TiO_2 and Fe_2O_3, K_2O is revealed in the Harkar variation diagrams (Figure 5), there are increasing trends in TiO_2 and Al_2O_3 with increasing SiO_2 values respectively implying a positive correlation. Conversely, Fe_2O_3 and K_2O exhibit descending trends signifying negative correlation, while other oxides are not definitive in their pattern. These negative correlations may be attributed to the fractionation of AlCa-Fe-Ti-Mg rich phases such as plagioclase, olivine, and pyroxene [20]. Negative correlation of Fe silica has often been attributed to magnetite crystallization in calc-alkaline series.

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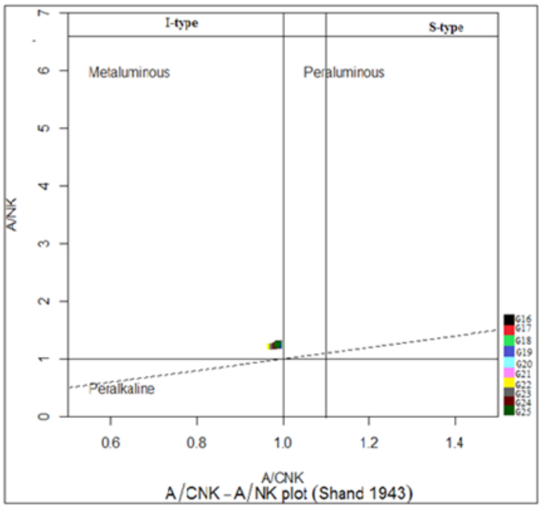

Fig. 4 Plot of Chemical classification of Iroko-granites using the Molecular ratio of alumina to alkalis after Shand (1943)

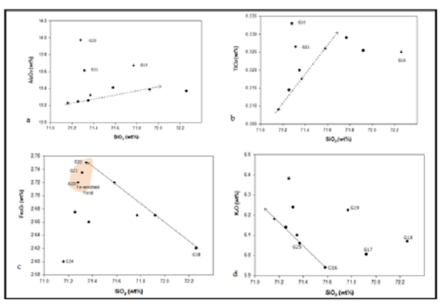

Fig.5: Harker diagrams of Iroko-granite data

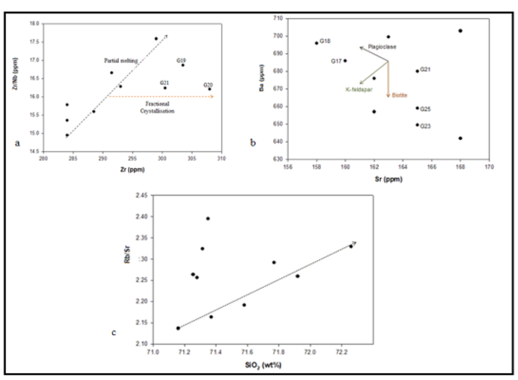

Fig. 6: Mineral Fractionation of Iroko-granites (after Yadav et al.,2016 and Huang et al.,2012)

5.1 Mineral Fractionation

The plot of Zr/Nb vs Zr (Figure 6a) show that most of Iroko-granites data plot along the partial melting trend, while a few of the data plot along the fractional crystallization trend. This suggests that the granites were largely derived from partial melting (of crustal materials) and for example samples "G21, G19, G20" may have undergone fractional crystallization of the melt at a later stage, with or without assimilation. In Figure 6b, the plot of Ba vs Sr suggest that the fractionation of biotite has occurred more in sample G21, G25, and G23, while fractionation of k-feldspar and plagioclase has occurred more in the other samples. Figure 6c is the plot of Rb/Sr Vs SiO_2, the positive correlation observable in most of the samples in this plot is implicative of the fractionation of feldspar, mica, and hornblende. These trends are less obvious in Rb vs SiO_2 and Ba vs MgO plots (not shown).

5.2 Trace Elements

The trace elements concentrations of Iroko-granites were normalized to Primitive mantle values after [20] with all samples showing consistent patterns with negative anomalies in Ba, Nb and Sr, a very strong depletion and positive anomalies of Rb, Th, U, La, Ce, Pb, Nd, Zr and Hf. In the primitive mantle-normalized multi-element spider diagram (Figure 7), the data exhibit notable spikes of enrichments in Rb and Th, and a significant depletion in TI.

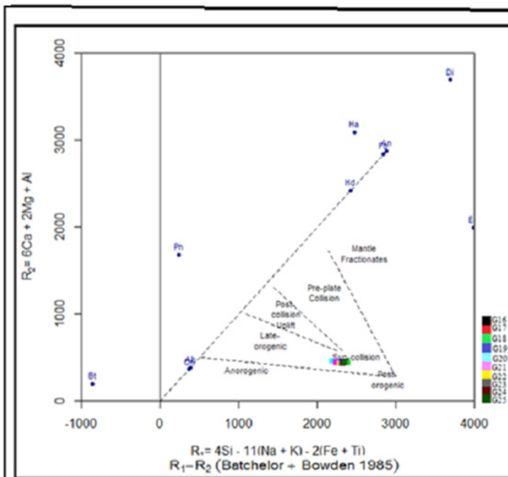

Fig.7 **Petrogenetic Model of Bachelor and Bowden (1985)**

5.3 Rare Earth Elements

REEs values of the analyzed Iroko-granites are given in (Table 1b). The data was Chondrite normalized after [20]. The average ∑REE =805.7ppm made up of 779.43ppm for light REE (La-Eu) constituting 97% and 26.27ppm for heavy REE (Gd-Lu) constituting 3% of the composition. The Chondrite normalized REE patterns show high LREE, low HREE with strong Eu depletion suggesting possible differentiation of the source magma.

5.4 Petrogenesis

Granitic rocks are known to have a wide range of sources, over all parts of the spectrum from pure mantle to pure crust. These sources show a significant correlation with tectonic setting [21]. Granites are the major magmatic products of most, if not all, collision belts, and may be subdivided tectonically according to the type of collision involved (continent- continent, continent-arc, arc-arc) and to the temporal relationship with the major deformation event (syn-collision, post-collision). Figure 8 is the petrogenetic discrimination model for Iroko-granites [22], where Iroko-granites plot in Syn-collision domain. The regional geology of the study area in Nigeria falls within Pan-African reactivated domain where [23] had opined that crustal extension and continental rifting at the margin of West African Craton during resulted in graben-like structures and this was followed by subsequent deposition of the rocks of the schist belts. The said crustal extension lead to N-S trending reactivated belt believed to have originated in a collision type orogeny in eastward dipping subduction zone. The N-S trending shear zones and other structures in the basement provided zones of weakness for the ascent of magmas, thereby causing the rocks to conform to the N -S to NE - SW structural trend of the country rocks. The Closure of the ocean along the craton margin about 600 Ma triggered crustal thickening in the Ghana-Togo-Nigeria domain and reactivation of the pre-existing rocks and emplacement of the Pan-African granites [7] as well as the metamorphism and eventual deformation of the sediments,. It is possible that it is in this arrangement that Iroko-granites and other granitoids were emplaced into a complex assemblage of ancient migmatite-gneisses and schistose rocks of the study area.

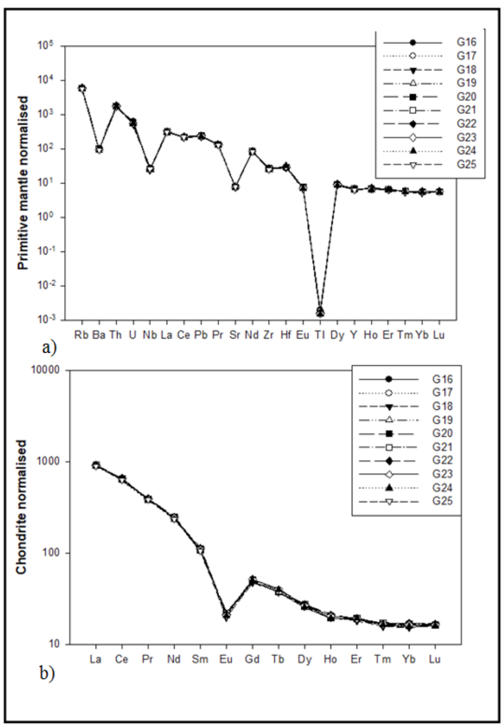

Figure 8. a and b Shows Primitive normalized spider diagram and Chondrite normalized patterns of Iroko-granites REE data respectively

6. Conclusion

The petrographic and geochemical characteristic evaluation of Iroko-grnites show that the rock is of high SiO_2 content, highly potassic, of sub-alkaline magmatic and calc-alkaline series. The granites are ferroan classified, exhibits characteristics of I-type and demonstrate metaluminous affinity. Chondrite-normalized REE diagram exhibit pronounced negative Eu-anomalies attributable to mineral fractional crystallization. The trace elements study is suggestive of pronounced fractional crystallization during evolution and the rock petrogenetically discriminates as Syn-collision provenance.

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References

[1] OlaOlorun, Oyinloye. Geology and geotechnical appraisal of some clay deposits around Ijero-Ekiti south western Nigeria: Implication for industrial uses. Pakistan journal of scientific and industrial research, Pak. J. Sci. Ind. Res., 2010, 53(3): 127-135.

[2] Okunlola, O. A, Akinola, O. O. Petrochemical characteristics of the Precambrian rare metal pegmatite of Oke-Asa area, South-western Nigeria:implication for Ta-Nb mineralization.RMZ-Material and Geoenvironment, 2010, 57(4): 525-538.

[3] Oyinloye, A.O. Physical and chemical characteristics of the residual clay deposits in Ijero-Ekiti area of Ekiti: Implication for industrial application. The Journal of Techno-Science, 1997, 1: 40-45.

[4] Rahaman, M.A. Recent advances in the study of the basement complex of Nigeria. In: Precambrian Geology of Nigeria, P.O. Oluyide, W.C. Mbonu, A.E. Ogezi,T.G. Egbuniwe, A.C. Ajibade and A.C. Umeji (eds.), Geological Survey of Nigeria, Esho Pub., Kaduna, Nigeria, 1988: 11-41.

[5] Turner, D.G. Upper proterozoic schist belts in Nigeria sector of the Pan-African province of west Africa. Precambrian Research, 1983, 21: 55-79.

[6] Matheis, G. The application of geochemical mapping in the tropical environment. In: Natural Resources and Development, Institute for Scientific Co-operation, Tubingen, Federal Republic of Germany, 1978, 8: 34-52.

[7] McCurry. The geology of the precambrian to lower paleozoic rocks of northern Nigeria, a review. In: Geology of Nigeria, C.A. Kogbe (ed.), Elizabethan

  DOI: https://doi.org/10.30564/jgr.v2i3.2246

Publishing Company, Lagos, Nigeria, 1976: 67-99.

[8] Grant, N.K. Geochronology of precambrian basement rocks from Ibadan, southwestern Nigeria. Earth and Planetary Science Letters, 1970, 10: 29-38.

[9] Okunlola, A.O., Akinola, O.O., Olorunfemi, A.O. Petrochemical Characteristics and Industrial Features of Talcose Rock on Ijero Area, Southwestern Nigeria. Ife Journal of Science, 2011, 13(2): 317- 326.

[10] Oyinloye, A.O., Adebayo, O.F. Petrophysical and chemical properties of calc-gneiss and clay deposit in Ijero-Ekiti area as industrial raw materials.Global Journal of Mechanical Engineering, 2005, 6: 30-34.

[11] Oyinloye, A. O. Physical and chemical characteristics of the residual clay deposits in Ijero-Ekiti area of Ekiti State, Nigeria. Implications for industrial application. Jour. Techno-Science, 1997, 1(1): 40-45.

[12] Oyinloye, A.O. Geology and Geotectonic Setting of the Basement Complex Rocks in Southwestern Nigeria: Implications on Provenance and Evolution. Earth and Environmental Sciences, 2011: 98-117. ISBN: 978-953-307-468-9

[13] Oversby, V.M. Lead isotopic study of aplites from the precambrian basement rocks near Ibadan, southwestern Nigeria. Earth and Planetary Science Letters, 1975, 27: 177-180.

[14] Grant. N.K., Rex, D.C., Freeth, S.J. Potassium-argon ages and strontium isotope ratio measurements from volcanic rocks in northeastern Nigeria. Contribution to Mineral and Petrology, 1972, 35: 277-292.

[15] Cox , K. G. , Bell , J. D., Pankhurst , R. J. The interpretation of igneous rocks. London: George Allen and Unwin, 1979.

[16] Miyashiro, A. Volcanic rock series in island arcs and active continental margins. Am. J. Sci., 1974, 274: 321-355.

[17] O'Connor J.T. A classification for quartz-rich igneous rocks based on feldspar ratios. Virginia: US Geological Survey Professional Paper B525, USGS, 1965: 79-84.

[18] Irvine, T.N., Baragar, W.R.A. A guide to the classification of common volcanic rocks. Can. J. Earth Sci. 8, 1971: 523-548.

[19] Frost B. R., C. G. Barnes, W. J. Collins, R. J. Arculus, D.J. Ellis, C. D. Frost. A geochemical classification for granitic rocks. Journal of Petrology. Academic Research Library, 2001, 42(11): 2033.

[20] Sun, S. S., McDonough, W. F. Chemical and isotopic systematics of oceanic basalts: implications for mantle composition and processes. In: Saunders, A. D. & Norry, M. J. (eds) Magmatism in the Ocean Basins. Geological Society, London, Special Publications, 1989, 42: 313-345.

[21] Pearce J. A., Harris N. B. W., Tindle A. G. Trace element discrimination diagrams for the tectonic interpretation of granitic rocks. J. Petrol., 1984, 25: 956-983.

[22] Batchelor R. A., Peter Bowden, Petrogenetic interpretation of granitoid rock using multicationic parameters, Chemical Geology, 1985, 48(1-4): 43-55 https://doi.org/10.1016/0009-2541(85)90034-8

[23] Elueze, A. A. Rift System for Proterozoic Schist belts in Nigeria, Tectonophysics, 1992, 209(1-4): 167-169. https://doi.org/10.1016/0040-1951(92)90019-3