International Journal of Engineering Research and Advanced Technology (IJERAT)

DOI: 10.31695/IJERAT.2022.8.3.3

E-ISSN : 2454-6135

Volume.8, No. 3
March -2022

Study of Origin, Geology and Geochemical Classification of the Granitoids of Imori Area, North Central Nigeria

Joro Joshua Dung[1*], Achuenu Ifeanyi[1]

[1]Department of Mining Engineering

University of Jos, Nigeria

ABSTRACT

Two distinct generations of granitiods in terms of space and time were identified in the Imori fields of north central Nigeria. The first generation is the Older Pan-Africa calc-alkaline granite suites (OPACG) which comprises the migmatite-gneiss and the porphyritic hornblende-biotite granite. The second group is the Younger Mesozoic alkali granite suites (YMAG). This comprises the rhyolite, biotite granite and arfvedsonite granite. The OPACG suites are characterized by depletion in SiO_2 ranging from 63.30 wt % - 68.38 wt % as compared to the YMAG suites which range from 70.41 wt % - 79.14 wt %. In addition, the OPACG suites are characterized by higher concentrations of MgO, fe_2O_3, Al_2O_3, TiO_2, CaO and Sr as compared to the YMAG suites. The YMAG suites are characterized by an excess of total alkaloids (Na_2O +K_2O), Cr, Nb, W, Ta, and lower concentrations of ferromagnesian minerals. These characteristic indicates that the OPACG suites are generated from deep seated crustal levels rocks with the possibility of mantle materials. The YMAG suites were originated from partial melting of crustal sialic materials. Both the trace element patterns of the OPACG suites and the YMAG suites indicate that each suite is co-magmatic.

Keywords: Pan-Africa calc-alkaline granite, Mesozoic alkali granite, Ferromagnesian minerals, Sialic materials, Co-magmatic.

1. INTRODUCTION

The Basement Complex in the Imori area was intruded by two distinct rock suites: OPACG and YMAG. Petrotectonic associations of these suites of igneous rocks were formed in response to similar geological conditions. However, each geological settings yield suites of comagmatic rocks having distinctive compositional attributes. These associations are either found at the divergent plate boundaries, convergent plate boundaries or at intraplate settings (within plate). It is also noted that some tectonic settings can evolve over geological time from one to another, e.g. continental intraplate regime overlying a rising mantle plume might evolve into a continental rift and then into a oceanic rift [12], and [15]. The objective of this paper is to relate and discussed the different granitoids complexes found in the Imori fields in north central Nigeria to a petrotectonic framework of geologic time tectonism.

The granitoids-complexes of Nigeria and Niger Republics constitute a mega-province, which is one of the best studied examples of mid-plate magmatism in the world. The Imori granitoids is part of the cycles of both intrusive and extrusive rocks of the OPACG and YMAG suites that characterized this maga-province in the Nigerian region. It is one of the granitic complexes that form the western edge of the popular Jos Plateau complexes, [5]. The Complex lies south of the Kudaru Complex and north of the Rishiwa complex (Fig. 1) covering a surface area of about30 $km^2$and it is oval in shape. The area is bounded by latitudes 10^0 27' and 10^0 30' N and longitudes 08^0 21' and 8^0 25' E, (Fig. 2). It is accessible through the trunk A Zaria – Jos road via a laterite (untarred) road from GidanWaya to Imori Complex.

2. GEOLOGY OF THE STUDY AREA

The geology of the study area formed part of the geology of Nigeria Basement Complex within the Pan-African terrain which has four broad of lithological units viz:-

i. A polycyclic basement of migmatites and gneisses. This is generally of amphibolites facies grade of metamorphic episodes [9]; [10]; and [19].
ii. Younger low to medium grade metasediment and metavolcanics which form distinct NNE-SSW trending belts within the migmatite-gneiss complex [18] ; [11].

iii. Syntectonic to late tectonic older granite rocks which intruded both the migmatite-gneiss basement and metasediments [8].

iv. Unmetamorphosed alkaline, calc-alkaline volcanic and hypabyssal rocks which overlie or intrude the basement-gniesses and granitic rocks associated with the lower Palaeozoic uplift following the Pan-African orogeny [16].

Ajibade [1]; [2] suggested that there are two generations of migmatite-gneiss of widely differing ages within the Nigerian Basement Complex – the early migmatites (high grade migmatites) and the Pan-African migmatites (injection – type migmatites). The Pan-African migmatites are formed mostly as a result of magmatic intrusions that altered pre Pan-African granitic rocks (e.g.,[7]).

The Imori Complex consists of petrotectonic associations of the Pan-African migmatite (the injection - type migmatite) and the porphyritic hornblende-biotite granite, related to the syntectonic to late tectonic, which both made up the OPACG suites and the unmetamorphosed anorogenic alkali granites which comprises of rhyolite, biotite granite and arfvedsonite granite which made up the YMAG suites. The orientations of joint sets in the complex are dominantly NW-SE direction (Fig. 2). The major and minor drainage systems in the area are structurally controlled by these faults.

3. PETROGRAPHIC DESCRIPTIONS

3.1 Migmatite-gniess

The migmatite underlies the entire area of the Imori fields. It is exposed out of the thick weathered overburden that surrounds the alkali granites and the porphyritic hornblende-biotite granite in the area. The sampled portion of the migmatite was the mesosome (a descriptive term for intermediate in composition between mafic melanosme and felsic leucosome). In hand specimen, the migmatite is medium to fine-grained texture. It has distinctively banded structure of grey to dark grey melanocratic and creamy to white colour leucocratic bands. The foliation on the migmatite is defined by the parallel arrangement of dark and light coloured minerals as revealed by the ptygmatic fold structure (Plate I). Under the microscope, the migmatite comprise subhedral and anhedral crystals of dark and light coloured minerals. The dark coloured

Figure 1: Mesozoic alkaline ring complexes in Nigeria (after Kinnaird, [12]). Arrow indicates the Imori Complex. Insert map of Africa showing the location of the Mesozoic alkaline complexes (after Bowden *et al*., [4]).

DOI : 10.31695/IJERAT.2022.8.3.3

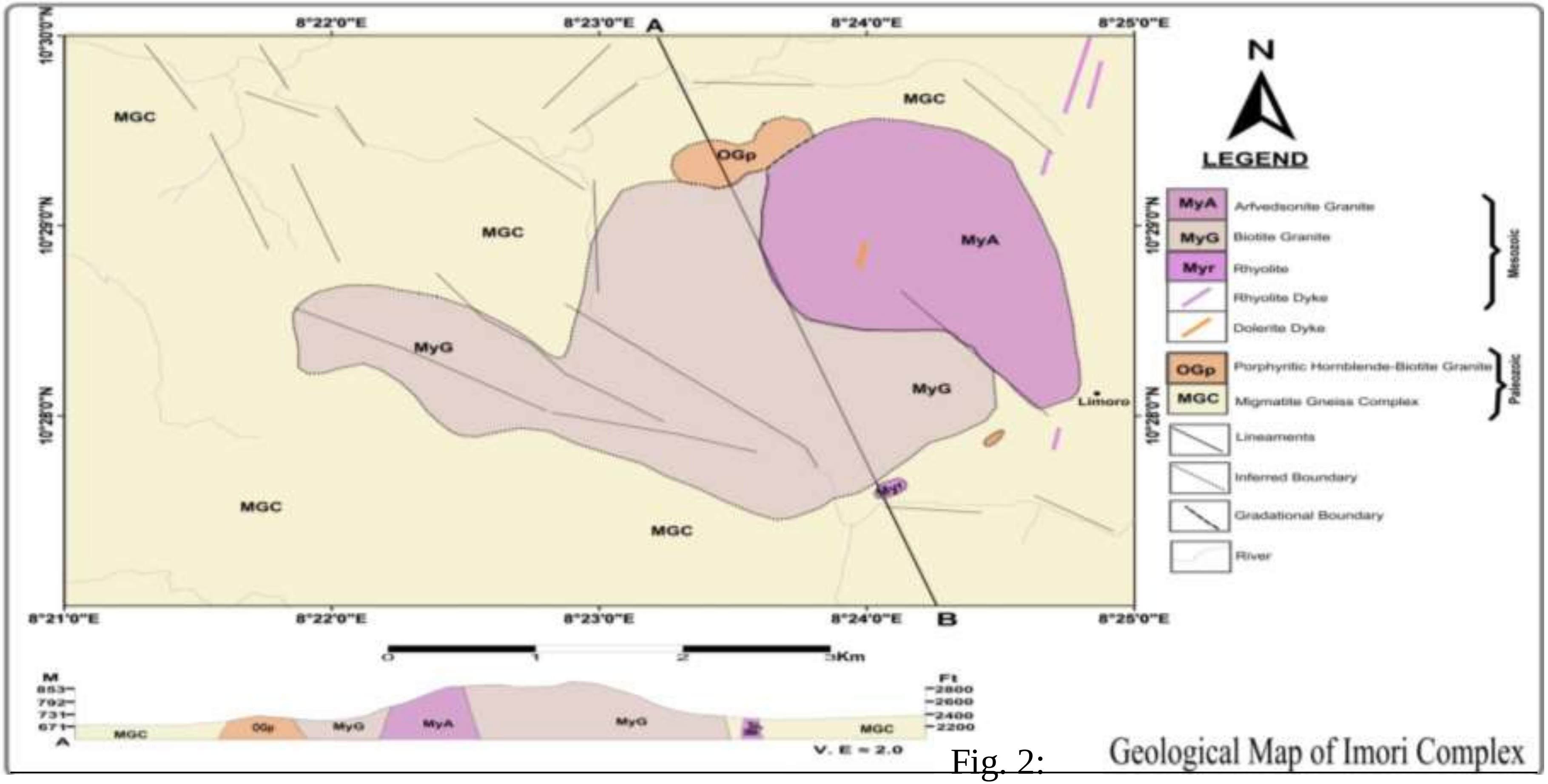


Fig. 2: Geological Map of Imori Complex

DOI : 10.31695/IJERAT.2022.8.3.3

minerals are hornblende, biotite and other opaque minerals. The feldspar and quartz are the light coloured minerals

3.2 Porphyritic Hornblende-Biotite Granite

The porphyritic hornblende-biotite granites are found both at the northern and southern peripheries of the Complex. The porphyritic hornblende-biotite granite outcrops in the northern edge of the Imori Complex occur in the form of a small arc. It has a gradational contact with the alkali granites suites southward. A small outcrop of the rock is also found in the south-eastern quadrant of the study area. In hand specimens, the porphyritic hornblende-biotite granites show presence of large phenocryst of potassium feldspar which gave the rocks their dominant colours. The phenocryst of potassium feldspar is set against matrix of quartz, plagioclase, hornblende and biotite in the groundmass. The roughly horizontal orientation of the potassium feldspar crystal visible in both hand specimen and thin section is suggestive that the crystal settled out from the magma melt in a preferred direction – possible due to the dominant NW-SE structural stress (Plate II). In thin section, the tabular feldspar phenocrysts are identified as orthoclase. The crystals of orthoclase feldspar are clustered together and appear dark grey in colour in XPL. The orthoclase shows moderate relief and does not exhibit pleochroism. Hornblende occurs as anhedral crystal, it is pleochroic pale brown in XPL. Biotite is pleochroic pale green to brown tints. The hornblende and biotite occur as aggregates intimately associated. Quartz occurs in groundmass as anhedral crystals that are clear and colourless with moderate relief. Quartz exhibit wavy extinction and quartz crystals clustered to larger feldspar crystal as poikilitic texture Plate III.

3.3 Rhyolite

The minor isolated rhyolite dyke in the south-eastern periphery is flattened and intruded into basement rock. In the northeast, another outcrop of rhyolite which is generally brownish in colour also intruded the basement rock. Under the microscope, the constituent minerals of the rhyolite are equigranular and are composed of quartz and alkali-rich feldspar. Rounded phynocryst of quartz is seen on the slide in XPL, they are resorbed as quartz xenocryst in the form of an enclave (PlateIV). Small sprays of both opaque minerals and amphibole occur as intergrowths with the feldspar thus conferring a crude spherulitic texture in the groundmass.

3.4 Biotite Granite

The biotite granite is the most widespread rock unit and occurs dominantly in the southern part of the Imori Complex. This rock constitute about two-third of the rocks of the Complex. Generally, the biotite granite is light brown in colour and is composed of feldspar, quartz and biotite. The feldspars are the most abundant minerals in the rock and are generally responsible for the overall colour of the rock.

Under the microscope, the biotite granite is composed of quartz, orthoclase, microcline, biotite and plagioclase in the form of narrower albiteexsolution lamellae (perthite). The common accessory mineral in this rock is hematite. Quartz crystal appears in the interstitial of perthitic crystals and is colourless to light yellow in colour in XPL. The mafic mineral, biotite occurs as tabular anhedral plate in small sheaf-like clusters. The biotite pleochroic haloe is brown to green, which aid its identification Plate V.

3.5 Arfvedsonite Granite

The arfvedsonite granite is the second major rock unit of the Imori Complex. It is the dominant rock in the north east of the Complex. It has the most imposing topography with highest peak being greater than 800m above sea levels. The predominant joint set on the arfvedsonite granites are oriented in NW-SE direction. Majority of the joints are filled with quartz as veins. The quartz veins are generally few centimetres wide and there is no any evidence of mineralization in them.

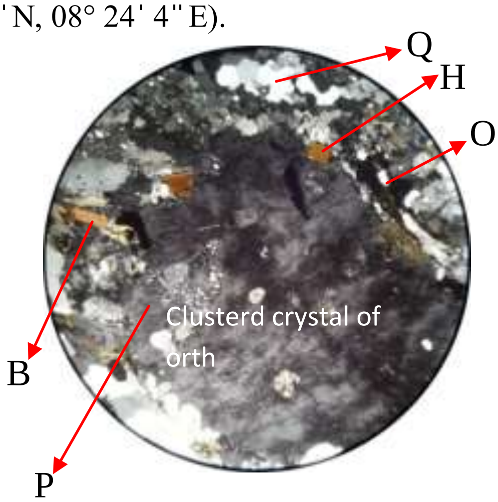
In hand-specimen the arfvedsonite granite is creamy white in colour as a result of its abundant orthoclase feldspar content. The minerals of the rock are feldspars, quartz, arfvedsonite and biotite. The arfvedsonite occurs as needle-like crystals which are randomly distributed throughout the rock. The rock is generally fine-grain.

Under the microscope, arfvedsonite is recognized by its pleochroic blue green absorption colour. It occurs as anhedral to subhedral grain and as interstitial acicular (needle like) crystals. Quartz occurs as aggregate, filling interstitial spaces among early paragenetic minerals. The feldspar is perthitic alkali feldspar. It is the most abundant mineral constituent in the rock (Plate VI).

DOI : 10.31695/IJERAT.2022.8.3.3

Plate I: Photograph of a ptygmatic fold on injected-type migmatite at the southern periphery of the Mesozoic alkaline granite. (10° 27' 52" N, 08° 24' 4" E).

Plate II: Photograph of porphyritic hornblende-biotite granite of northern part of the study area (10°29'41"N, 08°23'47"E)



Potomicrograph of porphyritic hornblende biotite granite depicting large crystal of clustered orthoclase with perthite in groundmass of quartz, hornblende, biotite and opaque mineral. O= Orthoclase, P= Perthite, B= Biotite, O= Opaque mineral, H= Honblende and Q= Quartz. A= XPL

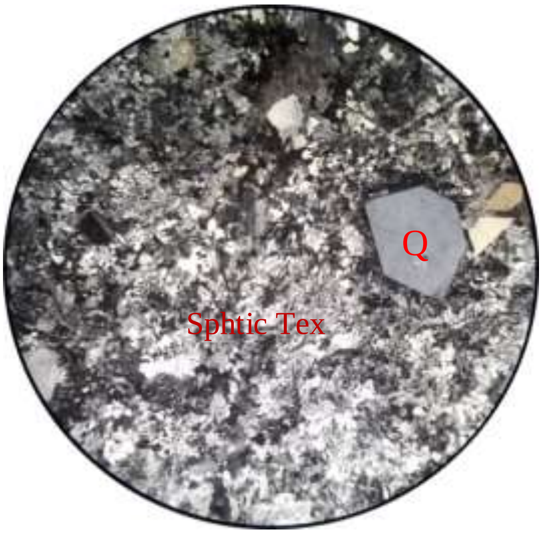


Plate IV: Photomicrograph of the light grey rhyolite with quartz xenocryst in fined-grained groundmass mainly of alkali feldspar. Q = quartz xenocryst with glass rim round it. Sphtic Txt= Spherulitic texture, XPL.

DOI : 10.31695/IJERAT.2022.8.3.3

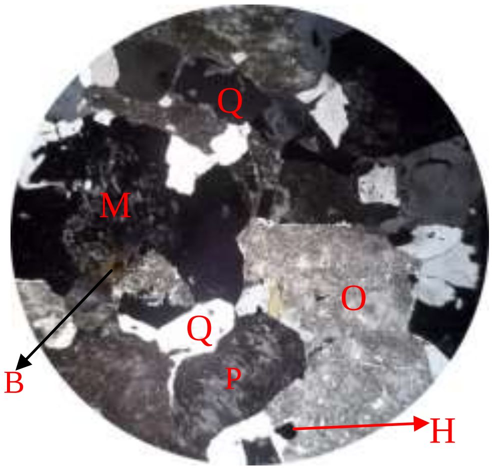


Plate V: Photomicrograph biotite granite. The albiteexsolution lamellae are seen in larger orthoclase and microcline as perthite. B= Biotite, O= Orthoclase, M= Microcline, H= Hematite, Q= Quartz, XPL,

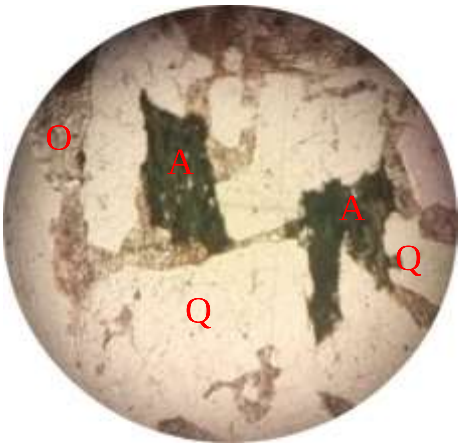


Plate VI: Photomicrograph of arfvedsonite granite with elongate crystal of arfvedsonite associating with quartz and feldspar. A= Arfvedsonite, O= Orthoclase, Q= Quartz, PPL= Plane polarised light.

4. GEOCHEMISTRY

Fifteen rock samples were selected for whole rock geochemical analysis. Major oxides, trace elements and rare earth elements (REEs) analysis were carried out using Inductively Coupled Plasma-Mass Spectrometer (ICP-MS) at the Activation Laboratories, Ontario Canada. Chemical composition of these representative samples are presented in (Tables 1, 2 and 3). The classification, correlation and the discrimination diagrams using the analytical data are plotted to characterize the granitic rocks, and to describe their geochemical characteristics and mineralization of the granitoids in the Complex.

DOI : 10.31695/IJERAT.2022.8.3.3

Table 1: Major oxides composition of the granitoids from Imori Complex (All values are in wt %).

	Basement Rocks							Alkali Granites							
	Migmatite		Porphy. Granite		Peg.	Rhyolite		Biotite Granite				Arfvedsonite Granite			
Sample	IM05	IM02	D03	D13	D01	IM11B	IM10	IM014	D09	D08	D17	D05	IM04	D04	D12
SiO_2	65.30	66.37	70.52	68.38	70.52	70.41	76.58	76.32	76.84	77.45	79.14	75.88	76.84	77.96	76.31
Al_2O_3	14.75	13.28	13.94	12.95	15.64	13.94	11.16	11.73	11.46	11.18	10.75	12.06	11.44	11.29	12.06
Fe_2O_3	6.35	6.46	3.21	6.41	1.12	3.42	2.87	1.31	1.37	1.29	1.27	1.34	1.45	1.26	1.21
MnO	0.098	0.075	0.037	0.088	0.018	0.037	0.018	0.025	0.021	0.019	0.02	0.019	0.019	0.017	0.013
MgO	1.74	1.01	0.49	0.41	0.14	0.52	0.01	0.07	0.08	0.07	0.07	0.05	0.08	0.09	0.06
CaO	2.19	2.66	1.44	1.99	1.16	1.34	0.09	0.50	0.55	0.43	0.41	0.47	0.52	0.38	0.28
Na_2O	2.62	2.42	2.86	2.49	4.64	3.04	3.35	3.40	3.37	3.24	3.23	3.39	3.25	3.04	3.32
K_2O	4.58	4.26	5.46	5.12	4.75	5.15	4.53	4.66	4.58	4.53	4.49	4.73	4.68	4.65	4.72
TiO_2	0.769	0.902	0.368	0.722	0.076	0.458	0.154	0.095	0.097	0.089	0.092	0.095	0.096	0.091	0.093
P_2O_5	0.25	0.28	0.12	0.22	0.06	0.19	0.02	0.02	<0.01	0.02	0.03	0.02	0.03	0.01	0.01
LOI	0.74	0.82	0.75	0.29	0.41	0.53	0.38	0.46	0.53	0.47	0.35	0.32	0.39	0.58	0.63
Total	99.38	98.53	99.19	99.06	98.54	99.03	99.17	98.58	98.90	98.79	99.87	98.38	98.80	99.51	98.71

DOI : 10.31695/IJERAT.2022.8.3.3

Table 2: Trace elements composition of granitoids from Imori Complex. (All values in ppm)

	Basement Rocks							Alkali Granites							
	Migmatite		Porphy. Granite		Peg.	Rhyolite		Biotite Granite				Arfvedsonite Granite			
Sample	IM05	IM02	D03	D13	D01	IM11	IM10	IM014	D09	D08	D17	D05	Im04	D04	D12
Be	7	3	3	3	3	2	6	11	5	5	7	4	5	5	3
Ba	253	862	881	1313	551	775	14	125	124	109	113	114	126	126	119
Sr	144	179	142	148	259	136	6	27	27	25	25	27	26	26	27
Y	29	67	27	87	90	37	46	58	65	27	44	44	52	52	52
Zr	197	498	322	900	25	321	799	134	108	111	100	114	92	92	109
Cr	110	50	50	40	40	40	90	110	60	160	130	50	150	150	150
Co	45	53	61	46	49	47	46	55	51	61	58	67	54	54	61
Ni	40	<20	<20	<20	<20	<20	<20	<20	<20	20	20	<20	<20	<20	<20
Zn	70	100	80	140	50	120	130	40	<30	40	40	50	<30	<30	40
Ga	27	25	23	26	23	25	35	25	29	28	28	24	27	27	24
Rb	332	180	203	208	144	173	208	239	206	233	230	240	202	202	228
Nb	15	30	18	38	6	24	103	41	27	30	28	32	24	24	34
Sn	7	7	3	4	3	2	11	4	3	5	4	7	3	3	3
Cs	13.3	3.3	2	2.4	2.1	2.6	1.4	4.1	2.9	3.5	5.1	6.1	1.9	1.9	2
Hf	5.0	13.9	8.7	22.5	1.2	8.8	24.5	6.8	4.5	5.4	4.7	5.6	4.1	4.1	5.3
Ta	1.7	2.2	1.1	2.3	0.9	1.5	8.4	4.6	3.5	4.5	3.6	4.2	2.6	2.6	3.5
W	179	273	379	268	306	278	289	358	308	389	369	445	332	332	393
Pb	55	33	28	25	59	46	22	21	17	35	24	21	33	33	19
Th	9.4	36.5	48	32.2	28.9	46.1	25.9	29.8	26.7	29.2	28.2	27.7	23.4	23.4	25
U	4.0	1.4	2.6	1.9	6.0	3.4	5.4	7.1	7.8	7.0	4.8	5.8s	3.0	3.0	4.8

DOI : 10.31695/IJERAT.2022.8.3.3

Table 3.Rare earth elements composition of granitoids from Imori Complex. (All values are in ppm).

	Basement Rocks							Alkali Granites							
	Migmatite		Porp. Granite		Peg.	Rhyolite		BiotiteGranite				Arfvedsonite Granite			
Sample	IM05	IM02	D03	D13	D01	IM11	IM10	IM014	D09	D08	D17	D05	Im04	D04	D12
La	33	132	142	191	18.8	128	17.5	42.9	45.1	40.2	42.4	36	51.1	51.1	51
Ce	68.6	269	280	365	38.5	256	78	83.9	86.8	81.2	83.1	79.8	91.6	91.6	90.9
Pr	8.02	29.4	29.7	44	4.41	28	6.37	9.07	9.24	8.81	8.87	7.34	10.3	10.3	10.6
Nd	29.2	103	99.6	158	16.8	96.6	24.1	30.1	31	29.2	29.5	23.8	34.9	34.9	34.7
Sm	6.3	19.4	16.8	28.2	4.9	17.5	7.2	7.5	7.3	7.5	6.6	5.6	7.9	7.9	8
Eu	1.1	2.2	1.72	3.47	0.72	1.44	0.32	0.26	0.32	0.24	0.29	0.26	0.36	0.36	0.34
Gd	5.2	15.8	10.9	21.7	7.5	12.7	6.4	8	8	7.5	6.3	5.7	8.4	8.4	7.6
Tb	0.9	2.4	1.4	3.1	1.8	1.7	1.3	1.5	1.5	1.4	1.2	1.1	1.5	1.5	1.4
Dy	5	13.9	6.5	18.4	13.2	8.5	8.9	9.6	.8	8.7	7.4	6.9	8.6	8.6	8.5
Ho	1	2.6	1	3.4	2.9	1.4	1.8	2	1.9	1.8	1.5	1.4	1.6	1.6	1.7
Er	2.7	6.9	2.5	9.3	8.8	3.4	5.9	5.5	5.9	5.3	4.2	4.1	4.4	4.4	4.8
Tm	0.39	0.97	0.29	1.25	1.31	0.41	0.98	0.81	0.87	0.8	0.65	0.64	0.65	0.65	0.68
Yb	2.5	5.7	1.6	7.5	8.7	2.3	6.7	5.1	5.8	5.2	4.3	4.2	4.1	4.1	4.5
Lu	0.39	0.83	0.24	1.18	1.29	0.36	1.07	0.77	0.89	0.76	0.68	0.65	0.57	0.57	0.67
ΣREE	164.3	604.1	594.25	855.5	129.63	558.31	166.54	207.01	205.42	198.61	196.99	177.49	225.98	225.98	225.39

DOI : 10.31695/IJERAT.2022.8.3.3

5. RESULTS

5.1 Classification Granitoids

The diagram in (Fig 3) is mostly useful for plutonic rocks classification, because the entire major element chemistry of the rock is used in the classification and the scheme is sufficiently general, to apply to all type of igneous rocks.

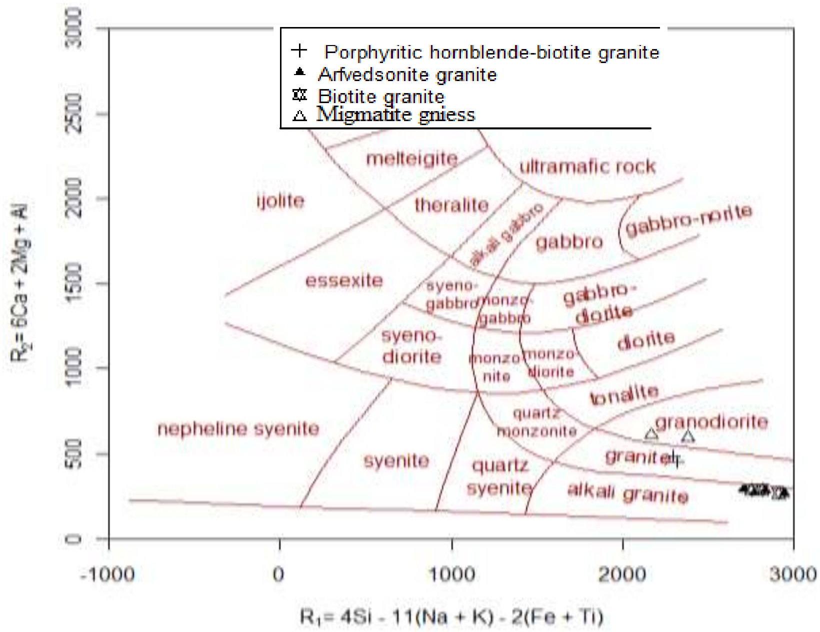


Fig 3: R1-R2 Multicationic classification of De la Roche *et al.*, [6] showing the alkali granites and the calc-alkaline granitiods of the study area

The molar A/CNK versus NK/A variation diagram (Fig. 4), [14] was used to illustrate the aluminium saturated index (ASI).

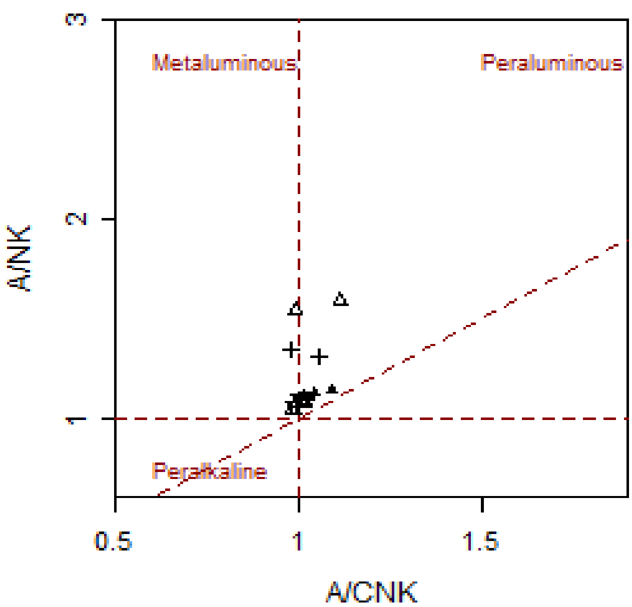


Figure 4: Chemical classification of the granitoids of the study area based Al_2O_3/Na_2O+K_2O versus $Al_2O_3/CaO+Na_2O+K_2O$ diagram (after Maniar and Piccoli, [14]). Symbols are same as in figure 3

5.2 Tectonic Regimes of Emplacement / Discrimination

The alkali granite suites straddle the fields of post orogenic and anarogenic granite, and the calc-alkaline suites where plotted in field syn-collision to post-collision uplift (Fig. 5). To further understand the regime granitoids emplaced, SiO_2 versus K_2O diagram [14] was plotted to relate the granite types and the environment of emplacement (Fig. 6).

DOI : 10.31695/IJERAT.2022.8.3.3

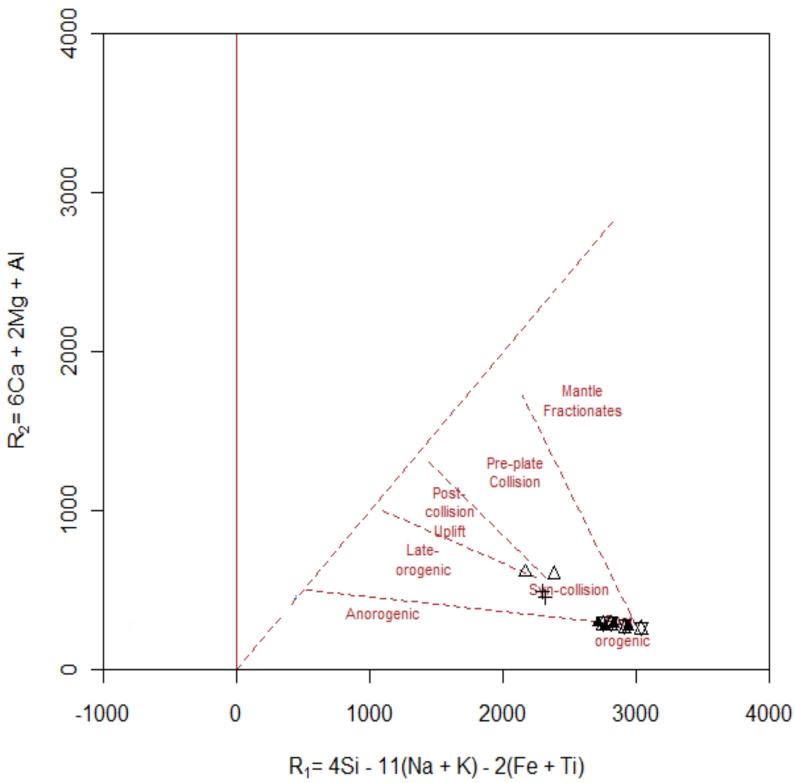


Figure 5: Multicationic classification plot showing petrogenetic / geodynamic fields for the granites from the study area (after Batchelor and Bowden, [3]). Symbols are same as in figure 3

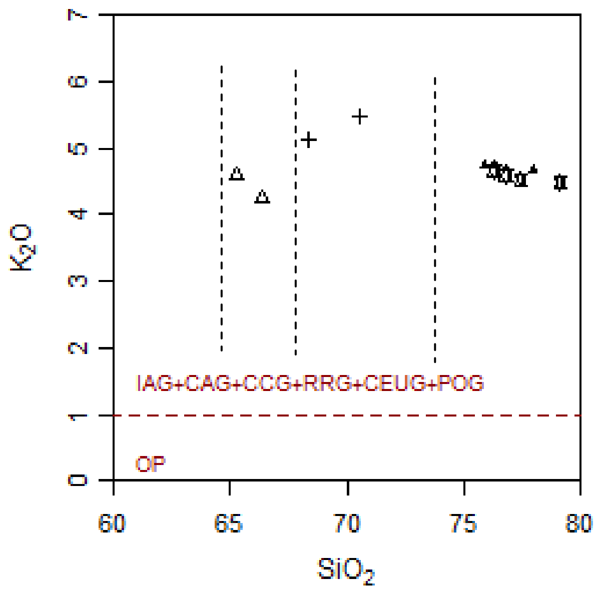


Figure 6: The SiO_2 versus K_2O diagram after Maniar and Piccoli, [14] showing the tectonic environment of the different rock units. Symbols are same as in figure 3

DOI : 10.31695/IJERAT.2022.8.3.3

5.3 Rare Earth Element Composition

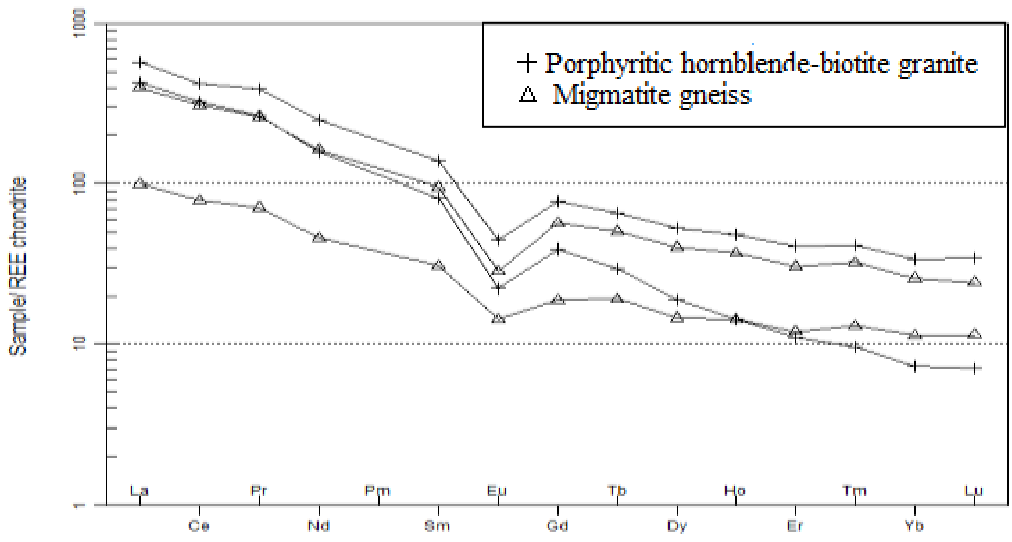


Figure 7: Chondrite-normalized REE plot (after Nakamura, [17] showing multi-element distribution patterns for the Pan-Africa calc alkaline granites suites of the Imori Complex.

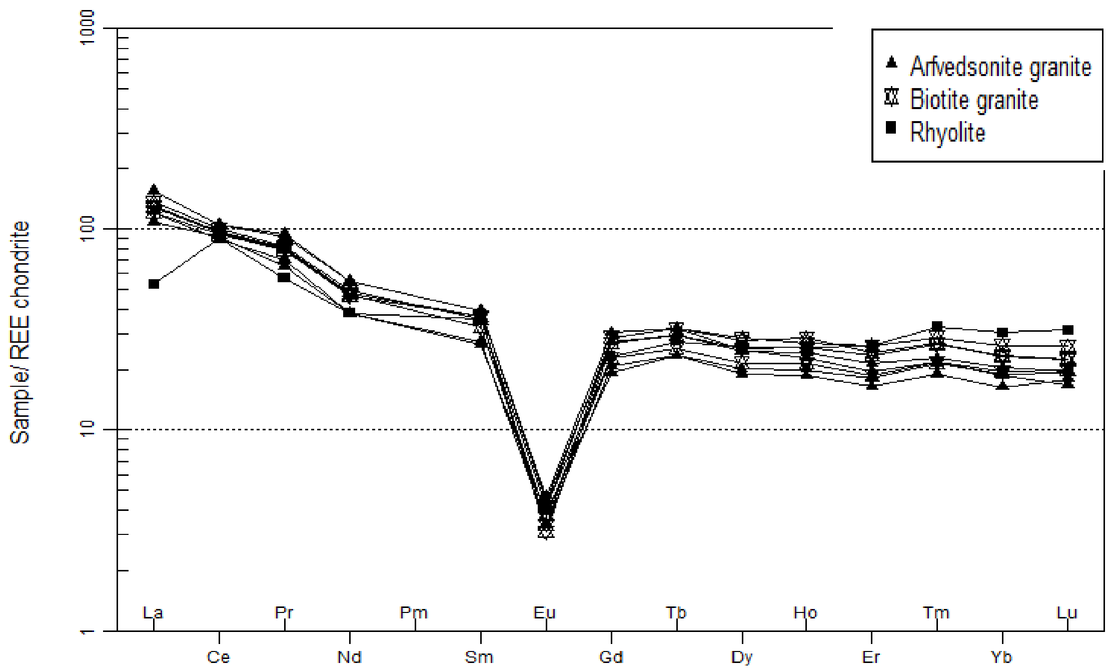


Figure 8: Chondrite-normalized REE plot (after Nakamura, [17] showing multi-element distribution patterns for Mesozoic alkali granites suites of the Imori Complex.

6. DISCUSSION

Geological field study and geochemical evidence shows that the OPACG suites and the YMAG suites in the study area are two different distinct rock types. The OPACG suites comprise the migmatite gniess and the porphyritic hornblende-biotite granites which enveloped the YMAG suites. Geochemically, the OPACG suites shows a depletion in SiO_2ranging from 63.30 wt % - 68.38 wt % when compared to the YMAGsuites which range from 70.41wt % - 79.14wt %, Na_2O range from 2.42 wt % -2.86 wt % compared to 3.04 wt % - 3.40 wt % respectively. The OPACG suites also show depletion in Nb, Cr, (Table 1 and 2). However, the

DOI : 10.31695/IJERAT.2022.8.3.3

OPACG suites shows higher ratio of MgO, Fe_2O_3, Al_2O_3, TiO_2, CaO and Sr contents, as compared to the YMAG suites. Thissuggested that the OPACG suites are generated at deep seated crustal levels with the possibility of mantle materials. The YMAGsuite which comprises the rhyolites, biotite granite and arfvedsonite granite shows a peraluminous geochemical signature (Fig. 4). They show an overall enrichment in SiO_2 content ranging from 70.41 wt % to 79.14 wt % and an excess of total alkaloids (Na_2O+K_2O) ranging from 7.61 wt % - 9.39 wt %. K_2O content is higher than Na_2O which suggest the preponderance of perthite, orthoclase and microline in the rocks. They also show higher content of Cr, Nb, W, Ta, and lower concentrations of ferromagnesian minerals as compared to the OPACG suites, thus suggesting that the magma that gave rise to the YMAG suites originated from partial melting of crustal sialic materials.

Based on the granitiods classification of R1–R2, the migmatite gniess and porhyritic hornblende-biotite granite of OPACG suites plot in the field in granodiorite and granite respectively while the biotite granite and arfvedsonite granite plot in the of alkali granite field(Fig. 3). Based on Alumina Saturation Index (ASI) plot (after [14], the OPACG suites and the YMAG suites are both slightly metaluninous to peraluminous, however, the OPACG suites have higher concentrations of A/CNK compared to the YMAG suites. This indicates the deep crustal origin of the OPACG suites, with the upper crustal origin of the YMAG suites (Fig. 4).
On the tectonic discrimination plots, (after Bachelor and Bowden, 1985), the OPACG suites straddled between syn-collision to post-collision uplift fields. This is suggestive that the OPACG suites are related to compression (syn-to-post-collision) tectonism regime that relate to subduction during the Pan-Africa orogeny. The YMAG suites plotted in the field of post collision granite settings (Fig. 5), and therefore suggesting that their emplacement unrelated to orogenic activities. To further understand the tectono-magmatic regime of emplacement, K_2O versus SiO_2 diagram [14] figure 6, the tectonic environment of the migmatite is associated with the continental collision granite (CCG) which resulted from the collision of the West Africa and Congo Cratons during the Pan-Africa orogeny. The porphyritic hornblende-biotite granite is associated with rift related environment (RRG) as a result of possible faulting and fracturing at the end of the Pan-African orogeny. The alkali granites is associated with post orogenic granite (POG), which suggested that their emplacement was after the Pan-Africa orogenic cycles.
The chondrite normalized REE patterns of the YMAG suites are generally similar to anorogenic granites all over the world; they are enriched with Light Rear Earth Element (LREE) and a rather flat Heavy Rear Earth Element (HREE) distribution pattern (Fig. 7 and 8).They exhibit Eu negative anomaly relative to chondritic values [17]. The chondrite normalized REE patterns for the OPACG suites is characterized by distinct enrichment of (LREE) and a less pronounce negative Eu anomaly as compared to the YMAG suites and slightly depleted HREE as also compared to the alkali granite suites. The REE patterns of both the OPACG suites and the YMAG suites indicate that the various rocksunite are co-magmatic.

7. CONCLUSION

The granitiods in the Imori fields are classified as the OPACG suites and the YMAG suites. The OPACG suites comprises of the migmatite-gneiss and porphyritic hornblende-biotite granite, they straddled between the syn-collision to post-collision uplift with higher wt % of ferromagnesian minerals as compared to the YMAG suites, indicating a source generated at deep crustal levels (mafic gneisses and amphibolites), which made them slightly metaluminous in nature. The REE patterns show that the OPACG siutes are co-magmatic.
The YMAG suites namely biotite granite, arvedsonite granite and the rhyolite are post-orogenic granites and they are not in any way relate to anyorogenic event. Their peraluminous signature and very high wt % of silica and (Na_2O + K_2O) indicated crustal source magma. The REE patterns suggest that the YMAG suite is co-magmatic. The granitoids are enriched in LREE and moderate concentration of HREE.

8. REFERENCE

1. Ajibade, A.C., Fitches, W.R. and Wright, J.B. (1987b). Basement cover relationships in the Minna region of the Pan-African domain of Nigeria. *Current Res. In: African Earth Science.* G. Matheis and H. Schantemeier .

2. Ajibade, A.C., Woakes, M., Rahaman, M.A. (1987a) Proterozoic crustal development in the Pan-African regime of Nigeria. *American Geoph. Union*,pp 259-271.
3. Batchelor R.A. and Bowden P. (1985) Petrogenetic interpretation of granitoid rock series using multicationic parameters [J]. *Chem. Geol*. 48, 43–55.

4. Bowden, P.; Black R.; Martin R.F.; Ike E.C.; Kinnaird, J.A. and Batchelor R.A. (1987). Niger-Nigerian alkaline ring-complexes: a classic example of African Phanerozoic anorogenic mid- plate magmatism in Alkaline igneous rocks. (J.G Fitton and B.G.J. Upton) (eds). Goel Soci., special publication, 30, pp 357-379.

DOI : 10.31695/IJERAT.2022.8.3.3

5. Bowden, P. and Kinnaird, J.A. (1984). Geology and mineralization of Nigerian anorogenic ring complexes. Geology (Hannover) B56, pp 3-65.

6. De la Roche, H., Leterrier, J., Grandclaude, P. and Marchal, M. (1980). A classification of volcanic and plutonic rocks using R_1,R_2-diagrams and major element analysis—its relationships with current nomenclature. Chemical Geology 29, pp 183–210.

7. Ekwueme, B.N. (1992). Rb-Sr age of Pan-African migmatites in the Oban massif SE Nigeria. Jour. of Afri.Earth Sci. 15, pp 65-72.

8. Fitches, W.R., Ajibade, A.C., Eqbuniwe, I.G.. Holt, R.W., and Wright J.B. (1985). Late Proterozoic Schist belt and plutonism in NW Nigeria. *Jour. Geol. Soc. London,* 142. pp. 319-337

9. Grant, N.K. (1970). Geochemistry of Precambrian basement rocks from Ibadan. South western Nigeria, *Earth Planet. Sci. Let., pp. 29-33*

10. Grant, N.K. (1971). A compilation of radiometric ages from Nigeria: *Jour. Mining Geology, V. 6, pp. 37-54.*

11. Grant, N.K. (1978). Structural distinction between a metasedimentary cover and an underlying Basement in the 600 Ma Old Pan-African domain of north western Nigeria. *Geol. Soc. Amer. Bull., 89,* pp. 50-58

12. Hess, P.C. 1989. Origins of igneous rocks. Cambridge, MA, Harvard University Press

13. Kinnaird, J.A. (1985). Hydrothermal alteration and mineralization of the alkaline anorogenic ring-complexes of Nigeria.*Journal of African Science.* Vol 3, pp 229-251.

14. Maniar P.D. and Piccoli P.M. (1989) Tectonic discrimination of granitoids [J]. *Geol. Soc.Am. Bull.* **101**, 635–643.

15. McBirney A.R. 1993. Igneous petrology: Second edition. Boston, Jones and Bartlett.

16. McCurry, P. (1976). The Geology of the Precambrian to Lower Palaeozoic rocks of Northern Nigeria – a review. *In Geology of Nigeria,* Ed. C.A. Kogbe, pp. 41-51. Elizabethan. Publ. Co. Lagos

17. Nakamura, N., (1974). Determination of REE, Ba, Fe, Mg, Na and K in carbonaceous and ordinary chondrites. GeochimicaetCosmochimicaActa, 38, pp 757- 775.
18. Rahaman, M.A. (1976a). Review of the Basement geology of southwestern Nigeria, *In Geology of Nigeria,* Ed. C.A. Kogbe, pp. 41-51. Elizabethan. Publ. Co. Lagos

19. Wright, E.P. (1971). Basement Complex. *Geol. Surv. Nigeria, Bull. 32(1), pp. 12-47*

* Corresponding Author E- mail: jjdungs@gmail.com

DOI : 10.31695/IJERAT.2022.8.3.3