Mineralogy, Geochemistry and Economic Potentials of Pegmatites around Egbe-Ejiba-Isanlu, Isanlu Sheet 225 Southwestern, Nigeria

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ABSTRACT

This study focused on the geochemistry and economic potentials of the rare metal mineralization within the pegmatites of the Egbe-Ejiba-Isanlu areas using geological, geophysical, and geochemical techniques. From a total of 92 fresh rock samples collected, 40 were cut into thin sections for petrographic studies, 20 cut and polished for ore microscopic studies while 30 were analysed for elemental composition of major oxides and trace elements, using XRF and ICPMS techniques respectively. Petrographic study shows that the area is underlain by Biotite Gneiss, Migmatitic Gneiss, Augen Gneiss, Banded Iron Formation (BIF), Quartzite, Quartz-mica Schist, Porphyritic Granites, Coarse-grained Granite, Quartz Diorite and Pegmatite. Structural data shows a dominant NNE-SSW trending lineaments with minor complimentary NNW-SSE trends. The Total Magnetic Intensity and Reduce to Equator images from aeromagnetic anomaly data were used to enhance existing inferred geological boundaries of adjoining lithological units. The Total Magnetic Intensity map (TMI) depicts magnetic anomaly values that ranges between 52.5-85.2. The map also shows prominent high magnetic anomaly (71.5nT- 84.0nT) in rocks of the eastern part of the area. The molecular plot of $Al_3O_2/CaO+Na_2O_3+K_2O$ versus SiO_2 reveals that the pegmatites have I-type characteristics. The K/Rb vs Cs discrimination diagram indicates that the pegmatites of the Egbe, Omi, Takete and Idofin areas are of the mineralized type. The geochemistry of some selected pegmatite samples shows enriched concentration values in ppm of 716.10, 19.68, 37.40, 92.00 and 481.70 for Rb, Cs, Ta, Sn and Nb respectively. These suggests that the pegmatites are rare metal type with enrichment trend of Rb>Nb>Sn>Ta>Cs, with strong negative Eu anomalies, suggesting that the pegmatites are of LCT-type. Ore microscopic studies show that the pegmatites are associated with tantalite, pyrite, chalcopyrite, tourmaline, and galena ores of economic values as evidenced in the high level of artisanal mining activities in the areas.

Keywords: rare metal, pegmatite, enrichment, anomaly, artisanal mining

INTRODUCTION

The study area covers Isanlu, Idofin, Ijagbe and Takete Isaho, Ejiba and Igbaruku and lies between longitude 5°30ˈ00"E and 5°54ˈ00"E and Latitude 8°09ˈ00"N and 8°20ˈ00"N (Figure 1). The area is underlain by seven major lithological units including Migmatitic Gneiss, Augen Gneiss, Banded Iron Formation (BIF), Quartzite, Mica schist, Diorite, Coarse grain Granite and Pegmatite. The gneisses form the basement on which the metasediments were unconformably overlain, deformed and infolded, and were together intruded by the Pan African Older granite suites. The schist outcrops around Ejiba area, with strong foliation, medium grained textured and melanocratic coloured. Quartz diorite was mapped as boulders with most of it covering Odo-Ara area (Figure 2).

The Pan African pegmatites of Nigeria occur mostly as dyke-like intrusions which vary from few meters to several kilometres in length and few centimeters to meters in width, trending mostly NW-SE (Akintola et al., 2012). Pegmatites are known worldwide to host economically important mineral deposits such as Tantalum, Niobium, Tin and Tungsten. Nigeria is a tin producing country and over 350,000 tons of cassiterite concentrates have been won from pegmatites in Nigeria between 1912 and 1944 (Jacobson and Webb, 1946).

Pegmatites within the study area occur as intrusion within the major rock types such as the granites, the migmatitic gneiss and the schist. They often occur as dykes which are vertically dipping and most trend in the N-S direction. These pegmatites host most of the tantalites mined within the study area especially around Ejiba and Igbaruku areas thereby constituting the targets for rare-metal mineralization in the area. Though these areas fall within the Kabba-Isanlu pegmatite belt (Okunlola, 2005) which is well known for heavy artisanal mining activities. However, there is no available record of a systematic study of the rare metal potentiality in the pegmatites of the area. This study, therefore, focuses on carrying out a scientific study of the distribution, mineralogy, geochemistry and economic viability of the rare metal mineralization in the area whose confirmation has become expedient to add to the geoscience database of the Nation.

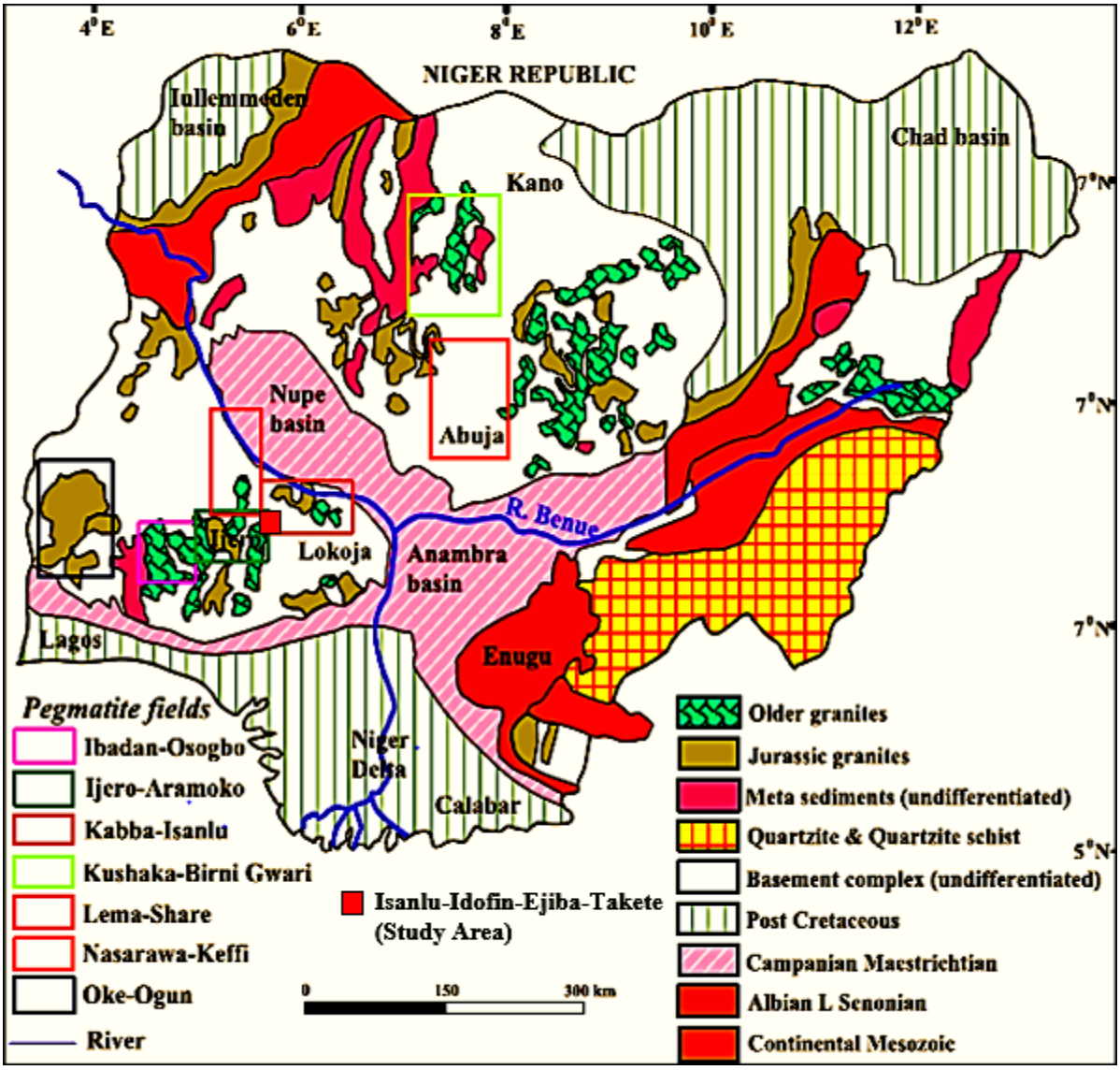


Figure 1- Simplified map of the geology of Nigeria (modified after Okunlola, 2005). Colored-edge boxes indicate the metallogeny of the rare-metal pegmatites of Nigeria.

REGIONAL GEOLOGY

The basement rocks are believed to be the results of at least four major orogenic cycles of deformation, metamorphism and remobilization corresponding to the Liberian (2,700 Ma), the Eburnean (2,000 Ma), the Kibaran (1,100 Ma), and the Pan-African cycles (600 Ma). The first three cycles were characterized by intense deformation and isoclinal folding accompanied by regional metamorphism, followed by extensive migmatization. The Pan-African deformation was accompanied by a regional metamorphism, migmatization and extensive granitization and

gneissification which produced syntectonic granites and homogeneous gneisses (Abaa 1983). The Nigerian rare–metal pegmatites formed over a time span of 562–534 Ma (Matheis and Caen Vachette, 1983) indicating the end of Pan–African magmatic activity.

GEOLOGICAL MAP OF ISANLU AREA, PART ISANLU SOUTHWEST SHEET 225

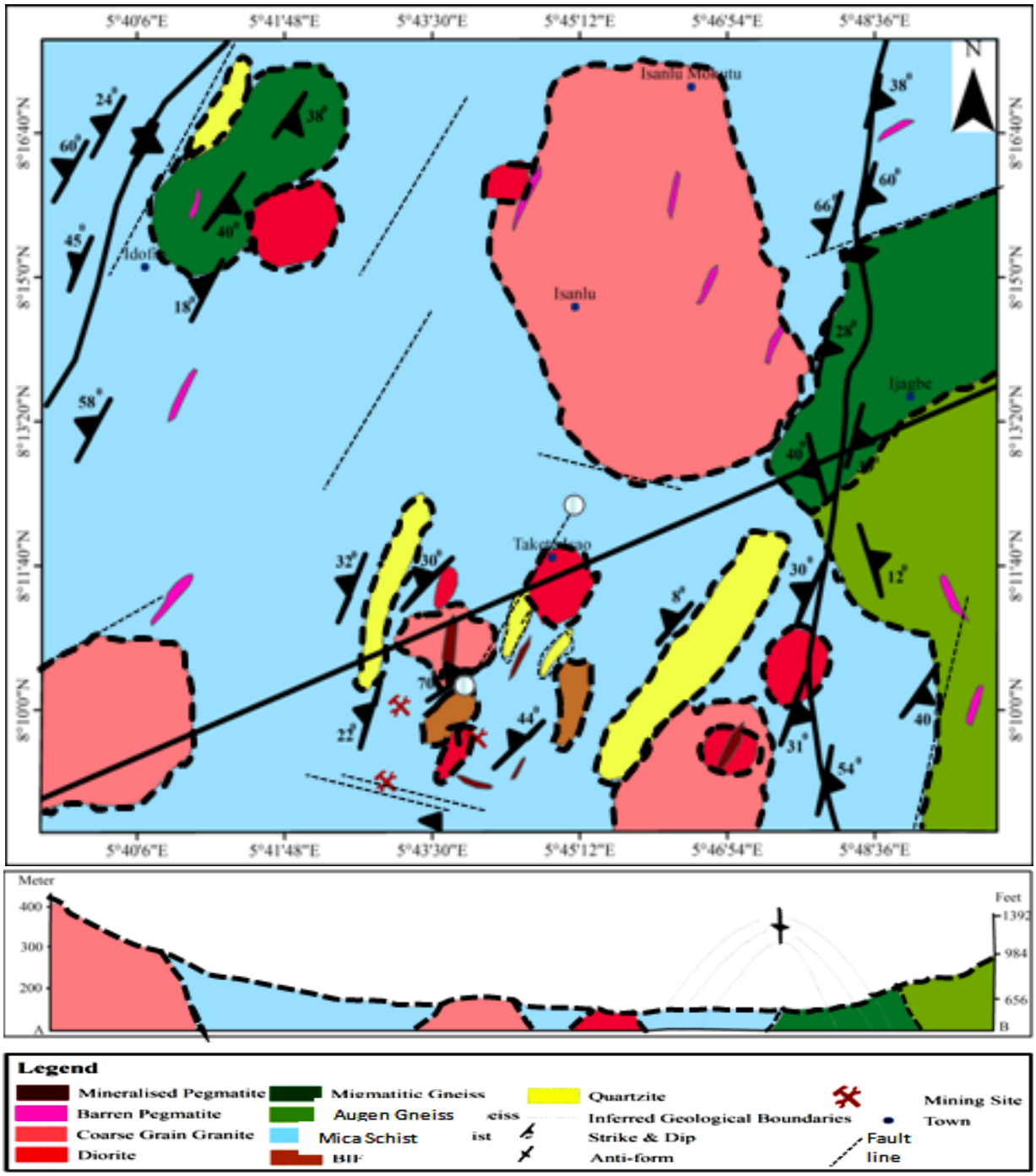


Figure 2: Geological map of Isanlu area showing lithological distribution.

Since the pegmatites are related to the Nigerian major fault lineament systems, the albitization and rare–metal may have been due to late-stage fluids available at the waning stage of the Pan–African metamorphic cycle (Ekwueme and Matheis, 1995) or due to sodium rich hydrothermal solution from the mantle along ancient lineaments (Wright, 1970). However, Matheis and Caen Vachette (1983) concluded that the rare–metal pegmatites of southwestern Nigeria are products of partial melting and leaching process of the basement units rather than the truly pegmatitic phase of the proximal Older Granite. It was also suggested by Matheis and Emofurieta (1987) that the rare-metal pegmatite mineralization of the southwestern Nigerian was derived from reactivation of deep-seated tectonic lineaments combined with partial melting and external fluid supply.

The rare-metal pegmatites trend in a NE-SW direction extending from Ife to Jos and appears to crosscut the geological boundary between the eastern and western Nigerian terranes (Kinnaird, 1984; Woakes et al., 1987). Recently, (Okunlola, 2005) defined the metallogeny of the rare-metal pegmatites of Nigeria, outlining it into seven broad fields; Ibadan-Osogbo, Ijero-Aramoko, Kabba-Isanlu, Kushaka-Birni Gwari, Lema-Share, Nasarawa-Keffi, and Oke-Ogun which have varied sizes, internal zoning, geochemistry, and mineralogy (Figure 1).

MATERIALS AND METHODS

This research work was carried out in five phases which includes desk study, geological field mapping, geophysical survey, laboratory work and data analysis in other to achieve the aim and objectives of this research work. The geological mapping was done using traverse method. Exposures of the different rock types occurring along river valleys, quarries, road-cuts, as well as on the break of slope of some hills were mapped. Thin sections were prepared for twenty (20) samples at the geoscience laboratory of the Department of Geology and Mineral Sciences at the Kwara State University (KWASU), Malete Nigeria out of about twenty 52 samples collected from the field. The petrographic study to examine the 20 thin sections was carried out using the transmitted light petrological microscope in the same laboratory. About fifteen selected rock samples were pulverized in a tungsten carbide mill at the Geoscience laboratory, KWASU and shipped to MS laboratory in Canada to determine the compositions which were analysed by Acid-Digestion Inductively Coupled Plasma-Mass Spectrometry (ICP-MS), for major and trace elements including rare-earth elements (REE).

Aeromagnetic data was acquired from the Nigeria Geological Survey Agency (NGSA) in other to ascertain the lithological boundaries and to extract the regional lineament possibly hosting the economic minerals within the study area. Six polished rock samples were studied under the reflected light microscope, using the immersion oil at the Al-Hikmah University Ilorin Kwara State with a view to ascertaining the ore minerals present within the pegmatites in the area. The plotting of structural data such as strike and dip values, trends of intrusions and joint directions was achieved with the aid of georose software while the mineral model analysis in petrographic studies was done using bar charts. The analysis and interpretation of the geochemical data obtained from the Canadian laboratory were achieved using Petrograph software.

FIELD OBSERVATIONS

Migmatitic Gneiss

The two major type of migmatite found in the study area are nebulite and stromatite (lith-par-lith banding). Migmatitic gneiss dominated the NE and NW part of the study area, grading into the Schist at the NE part. Most of the migmatitic gneisses outcrop as low-lying exposures, covering an average area of about 150m by 100m in dimention. Most of the outcrops are hosting pegmatitic veins of up to 2 meters width in dimension. The migmatitic gneiss is a deep grey to black, fine to medium grained texture. The average dominant strike and dip direction is 08°/44°W. The major structures include fold, joint, fault, pinch and swell etc. The quartz has subhedral shape with high relief in thin section while plagioclase feldspar shows multiple twining and subhedral crystal shape. Modal analysis as observed in thin section are Quartz (25%), Myrmekite (20%), Plagioclase (10%), Microcline (20) and Biotite (25%) (Figures 3 and 4).



Figure 3: An Outcrop of Migmatitic Gneiss showing the palaesomes and leucosomes (N08° 09' 28'' and E005 47' 2.5'').



Figure 4: An outcrop of Migmatitic gneiss at Ikoro area (N08°09′00” and E005°30′12”)

Augen Gneiss

The megacrists constituting the augen have an average size of about 40mm by 30mm and it is dominated by quartz and plagioclase feldspar within the groundmass of quartz, feldspar, amphibole and biotite. The gneissic texture of the rock is intruded by quartz veins trending in the northern direction. Other structures such as fold, fault were also mapped on the outcrop. Average strike and dip is 52°/18°E. The rock outcrops as low-lying exposures and as big boulders with an average size of 2m by 1m. Quartz and Plagioclase feldspar with multiple twining and euhedral crystal shape dominate the mineralogy of the rock. Micro-faults trending NW-SE were observed in the thin section. Modal analysis as observed in thin section are Quartz (50%), Plagioclase (10%), Microcline (20) and Biotite (20%) (Figures 4 and 5).



Figure 5: Open fold in Augen Gneiss outcrop having an amplitude of 10cm and a wavelength of about 60cm (N08°13′6.6′′ and E004°51′52′′).

Banded Iron Formation

The iron-formation is exposed at the crustal zones of a series of discrete northeast-southwest trending ridges over a distance of about 6 km, near Takete village, some 10 km south of Isanlu-Makutu town.

Quartzite

The quartzite is composed of interlocking small granules of quartz with an overall sugary texture and a vitreous lustre. It is brittle, crystalline and scratches glass. The grains of quartz are wedged together by silica. The rock is well exposed along the road exposure at Takete village, having an average exposed height of about 2 meters above the surrounding country. The rock also outcrops at the extreme NW part of the study area. The mineralogical composition of the rock as observed in the photomicrograph includes quartz (95%) and subordinate muscovite (5%).

Mica Schist

Schist is dominant in the study area, occurring as background rock which host about 90% of the pegmatite around Takete area where the artisanal miners are currently working at subsistence level. The Mica outcrops mostly as low-lying weathered exposures but in localized areas, where shearing has made the rock more indurated and competent, stand as high ridges having an average height of about 30 meters above the surrounding country, exhibiting a definite boundary with the coarse grain granite at Takete village. Its mineralogy includes quartz, feldspar, biotite, muscovite, beryl and tantalite. It has schistose banding and intruded by pegmatite veins, most of which trends in the N-S direction. Additionally, the dominant strike and dip directions in the schist are 002°/32°w and joints trend in the direction 064°. The quartz grains show anhedral shape with high relief in thin section. Modal analysis as observed in thin section are Quartz (40%), Muscovite (20%), Plagioclase (10%), Microcline (10) and Biotite (10%), Amphibole (10%).

Diorite

It is occurring as a low-lying dome shaped outcrop, having an average size of about 3m by 2m in area extent and up to 1m in height. Elsewhere, the rock is well exposed along the river channel around Takete where it outcrops as discrete boulders having an average size of 2m by 0.5m with abundant mafic minerals such as biotite. The quartz is euhedral with high relief while plagioclase feldspar shows multiple twining with biotite dominate the minerals. Modal analysis as observed in thin section are Quartz (25%), Plagioclase (20%), Sphene (5%) and Biotite (25%), Orthoclase (15%), Hornblende (10%).

Coarse Grained Granite

The coarse-grained granite outcrops between Takete to Isanlu (Latitude N08°23'00'' and Longitude E004°49'00), outcropping as series of discontinuous dome shaped hills of about 70m wide and trends in the direction N-S with an average height of about 10m above the mean sea level. The rock shows phaneritic texture and leucocratic in colour. The dominant constituent mineral from hand specimen observation are quartz, microcline, plagioclase, biotite and orthoclase. Fault and joints constitute the dominant structure mapped on outcrops of this rock. Quartz is anhedral in shape with high relief in thin section. Plagioclase feldspar shows multiple twining. The modal composition as observed in thin section includes Quartz (30%), Plagioclase (35%), Microcline (14) and Biotite (5%), Zircon (1%) and Orthoclase (15%).

Pegmatites

The rock is well exposed mostly as veins which massive intruded the Muscovite Biotite Schist around Takete-Isaho axis (N08°10'52'' and E005°46'25''). The emplacement of some of the pegmatites veins were observed to be syntectonic and have been caught up at the waning stage of the Pan African orogeny. These pegmatites are folded within the Migmatitic Gneiss around Isanlu area. Most of the pegmatites are concordant with the foliation plane and trends in the N-S direction with few discordant ones trending in the E-W direction. Some of the concordant pegmatite veins coalesce into dykes with widths ranging between 0.5m - 10m in size. Most of the pegmatite at Takete are mineralized and are hosting economic minerals such as beryl and tantalite which are currently being mine by artisanal miners.

The mineral composition includes quartz, sericite, plagioclase and microcline. The quartz has subhedral to euhedral shape while the plagioclase feldspar shows multiple twining and dominates the rock. Modal composition as observed in thin section include Quartz (20%), Plagioclase (40%), Microcline (25) Muscovite (10%), Sericite (5%) (Figure 6). Ore microscopy study shows that some most pegmatites and the main schistose host rock around Isanlu area are mineralized with some economic minerals such as Tantalum, iron ore, galena, chalcopyrite, native antimony and garnet etc. and, these, when properly explored and harnessed can boost the economic potential, not only of the study area but of the Nation as a whole.

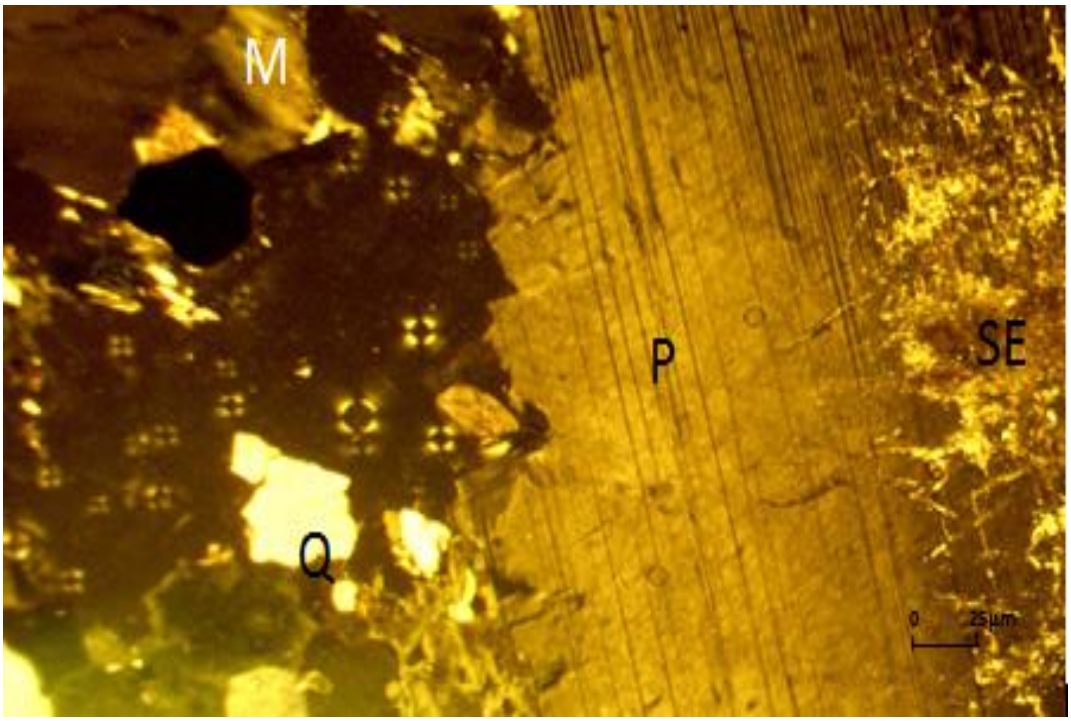


Figure 6: Photomicrograph of Pegmatite on cross polarized M- Microcline, P- Plagioclase, Q- Quartz, SE- Sericite

STRUCTURAL GEOLOGY

Ductile structures which include folds, foliations, pinch and swell and Brittle structures such as fractures (joint and fault) were mapped on various scales on some outcrops in the field. Most of the foliated rocks mapped have strikes that dominantly trend in the NE-SW direction and dip mostly westerly with few easterly dips. This is consistent with the established NE-SW structural grains in the Nigeria Basement Complex. The dominant open joint direction in the area is NNE-SSW with fewer complimentary NNW-SSE trending joints (Figure 7). Most of the joints are healed with pegmatite and quartz vein and trends in the NNE-SSW direction (Figure 8). Subordinate healed joints trends along ENE-WSW, W-E and NW-SE directions.

The unhealed joints measured from fractured rocks were mapped to be trending in the WNW-ESE direction. Asymmetrical folds occur within the migmatitic gneisses of Igbaruku area. Foliation planes measured on the augen gneiss and migmatite gneiss particularly in the southeastern sector of the study area were observed to be trending in the NW-SE direction where they defined the axes of a regional antiformal fold in conformity with the general structural trend in the Basement terrain. A conjugate fault system was mapped on the augen gneiss outcrop which shows that the rock has suffered from polyphase tectonic deformation (Figure 9).

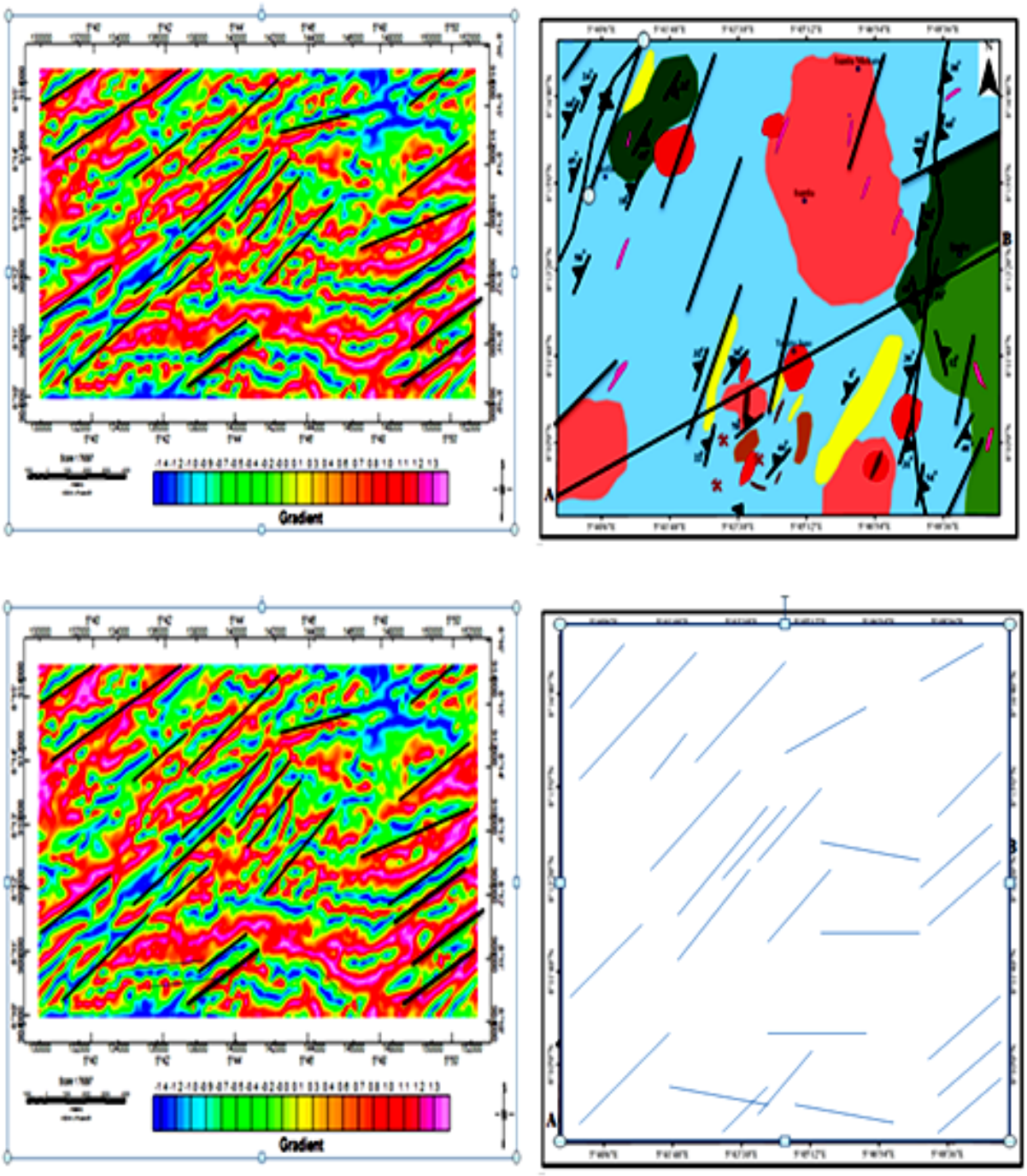


Figure 7: Lineament map of the study area derived from TDR map showing the dominant NE-SW trends

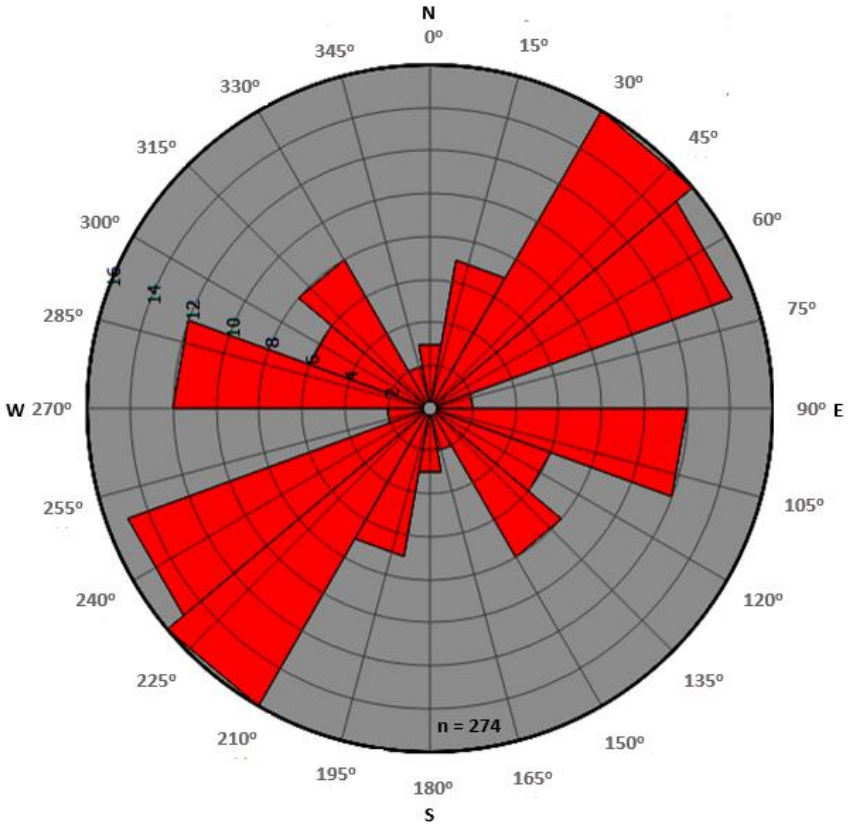


Figure 8: Rosette diagram of the trend of joints healed with pegmatite and quartz veins.



Figure 9: Conjugate fault on augen Gneiss outcrop. (N08°13′6.6′′ and E005°51′52′′).

DISCUSSION

Isanlu-Egbe area is underlain by rocks of the Basement Complex of Nigeria including the Migmatitic Gneiss and Augen Gneiss that are overlain by the Banded Iron Formation, Quartzite and Schist which are together intruded by rocks of the Older Granite suites mainly Diorite and Coarse-grained Granite. This is later followed by late-stage fractionation and crystallization of Pegmatitic and Aplitic dyke as well as Vein Quartz. This is consistent with the work of Rahaman (1989).

Whole rock geochemical analysis of the fresh samples obtained from the study area were sent to MS Lab at Canada to determine the geochemical elemental composition of the selected samples. Oxides of major elements provide the bases for the classification of rock types, include proper naming of the rocks. The rare elements concentration was used for tectonic discrimination and classification as well as provides the bases for determining the rare metal mineralization potential of the various rock types. The major oxides compositions of the pegmatites in the study area include SiO_2 content which ranges from 70-77.75 wt%, Al_2O_3 ranges from 11.07-18.74 wt %. The CaO content ranges from 0.13-0.34 wt.%, Na_2O from 2.63-4.29 wt.% while K_2O content ranges from 2.84-4.83 wt.% and TiO_2, from 0.2-4.72 wt.%, while Ta varies from 2.5-19.83 wt %. The high silica content in pegmatite suggest that they are corundum normative. The high concentration of tantalum (Ta) is also suggestive of the fact that most of the pegmatites in the area are highly mineralized in tantalite.

The K_2O versus SiO_2 general classification plot of Lebas et al (1986) for granitoids of the study area shows the granitoids displaying rhyolitic composition with only the porphyritic diorite having basaltic affinity (Figure 10). The Yb+Ta versus Rb tectonic discrimination diagram of Pearce et al., (1984) for the granitoids of the Egbe-Isanlu area revealed that the granitoids are of the within plate origin except for the diorite which lies in the field of oceanic ridge granite (Figure 11). Figure 12 shows the K/Rb versus Cs discrimination diagram of Morteani et al., (2000), suggesting the degree of fractionation and mineralisation pattern of the pegmatites in which the pegmatites around the southern and western part of Takete and Idofin areas area mineralized while those around Isanlu and northern part of Takete are the baren type.

The bivariate TiO_2 versus SiO_2 discrimination diagram of Tarney (1977) and the Na_2O/Al_2O_3 versus K_2O/Al_2O_3 plot of Garrels and Mackenzie, 1971 for the igneous and metasedimentary rocks of the area suggest that the granitoids are sedimentary in origin except for diorite and pegmatites which shows

igneous affinity with contributions from sedimentary source during their prolonged fractionation. The $Al_2O_3/(Na_2O+K_2O)$ versus $Al_2O_3/(CaO+Na_2O+K_2O)$ discrimination diagram of Shand (1943) suggests that the granites and pegmatites are metaluminous to peraluminous in character, which is consistent with the work of Usman (2015) around Egbe area. Trace elements are known to serve as a guide to the processes and origin of igneous rocks as they may exhibit concentration range that is greater than major elements, suggesting mineralization enrichment.

The REE distribution pattern for rocks of the study area, as shown on the Chondrite normalized plot of Nakamura (1974) for the rare-earth elements (REE), generally revealed slight enrichments in light rare earth elements (LREE) or near flat REE fractionation pattern with negative Eu anomalies. The mineralized pegmatites however exhibit this low to flat fractionation pattern but with positive Eu anomaly, suggesting the dominance of plagioclase in the melt with little or no presence of hornblende in the felsic melt. The dominant presence of plagioclase in the melt played a major role during fractionation in the presence of subordinate hornblende with little or no role in the magmatic segregation (Figure 13). This is evident in the measured geochemical data (Tables 1 and 2) which revealed that the pegmatites around Takete area are highly enrich in Ta (53.2ppm), Rb (784ppm), Nb (90.7ppm) while their crustal abundance are Ta (2.2ppm), Rb (112ppm), Nb (25ppm). The barren pegmatites at the northern areas of Takete and Isanlu shows a progressive enrichment in HREE and exhibit the lowest Eu anormaly. These barren pegmatites are characterized by low Rb, Cs, Ta and Nb but high Ba, Sr and K/Rb, while the rare-metal pegmatites are chemically enriched in Eu, Rb, Cs and Ta.

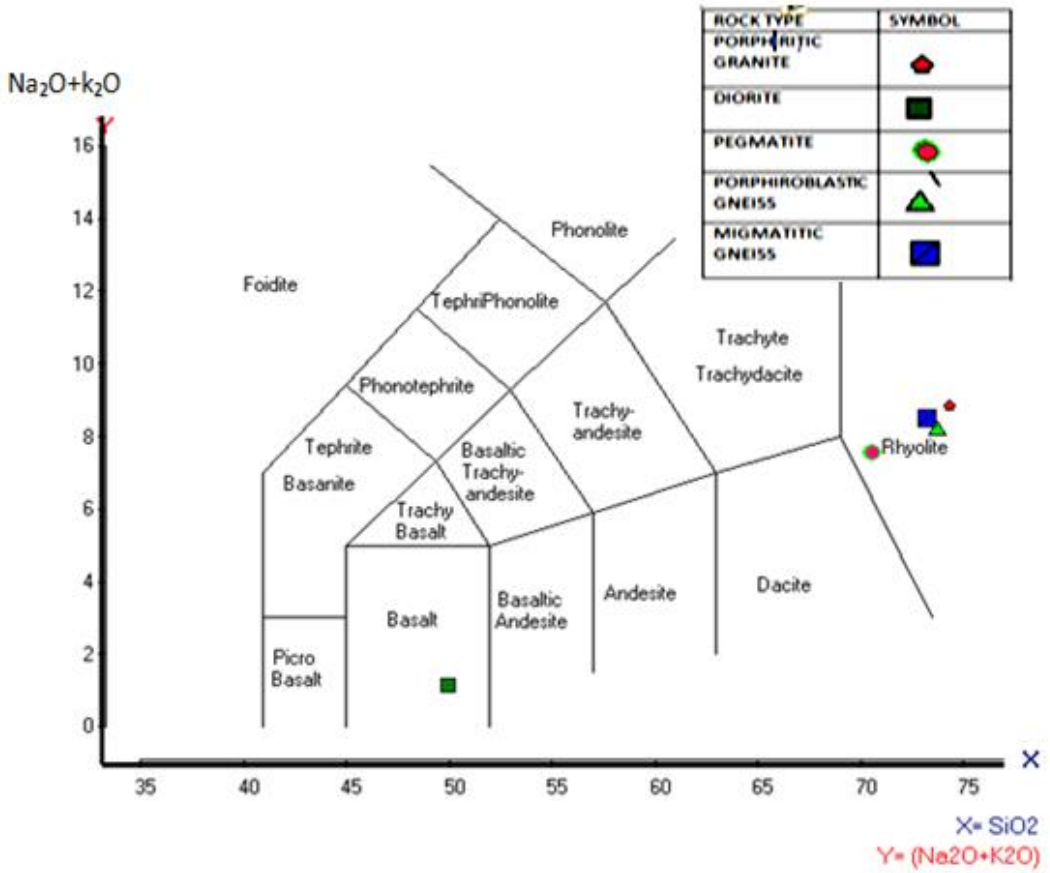


Figure 10: General Classification of rock type using K20-Sio2 diagram (After Middlemost Lebas et al 1986).

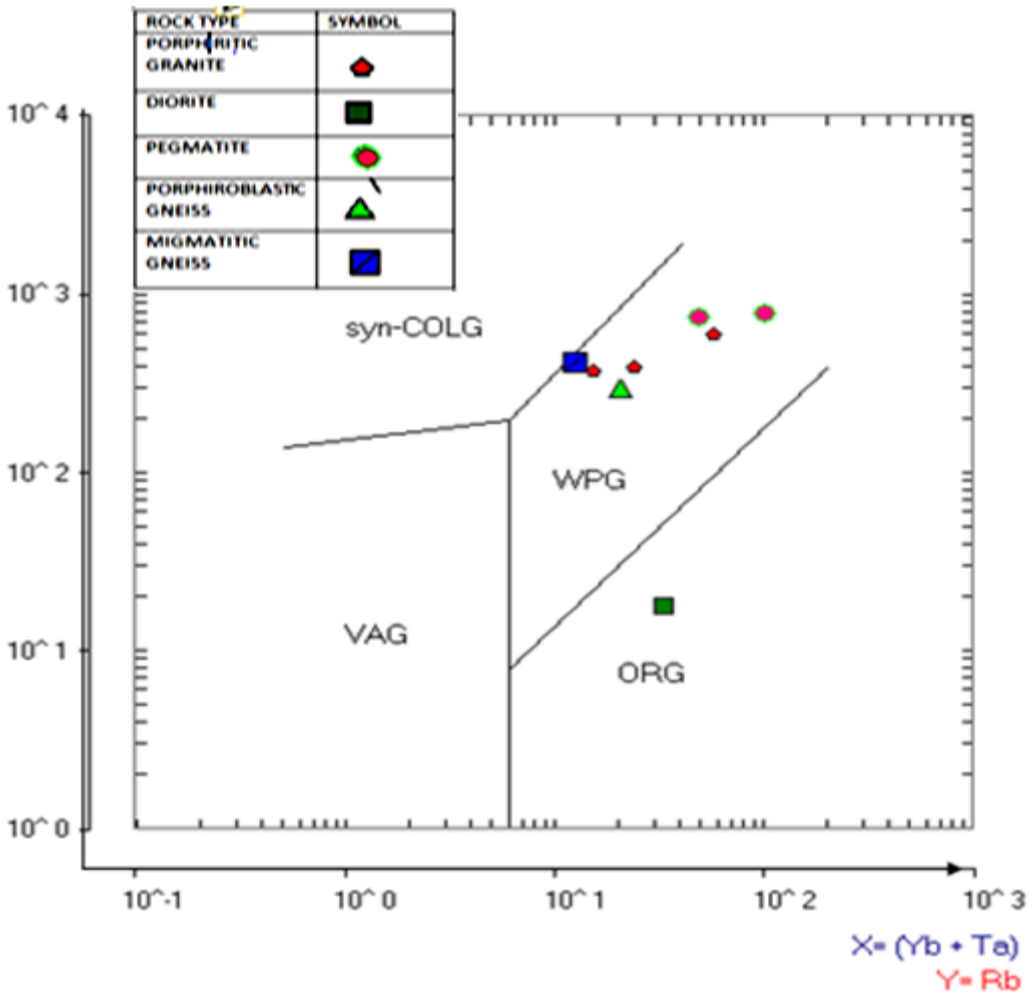


Figure 11: The tectonic discrimination diagram of Yb+Ta versus Rb for the granitoids of Isanlu area (ORG - oceanic ridge granites; COLG - collision granites; VAG - volcanic arc granites and WPG - within plate granites) (After Pearce et al, 1984)

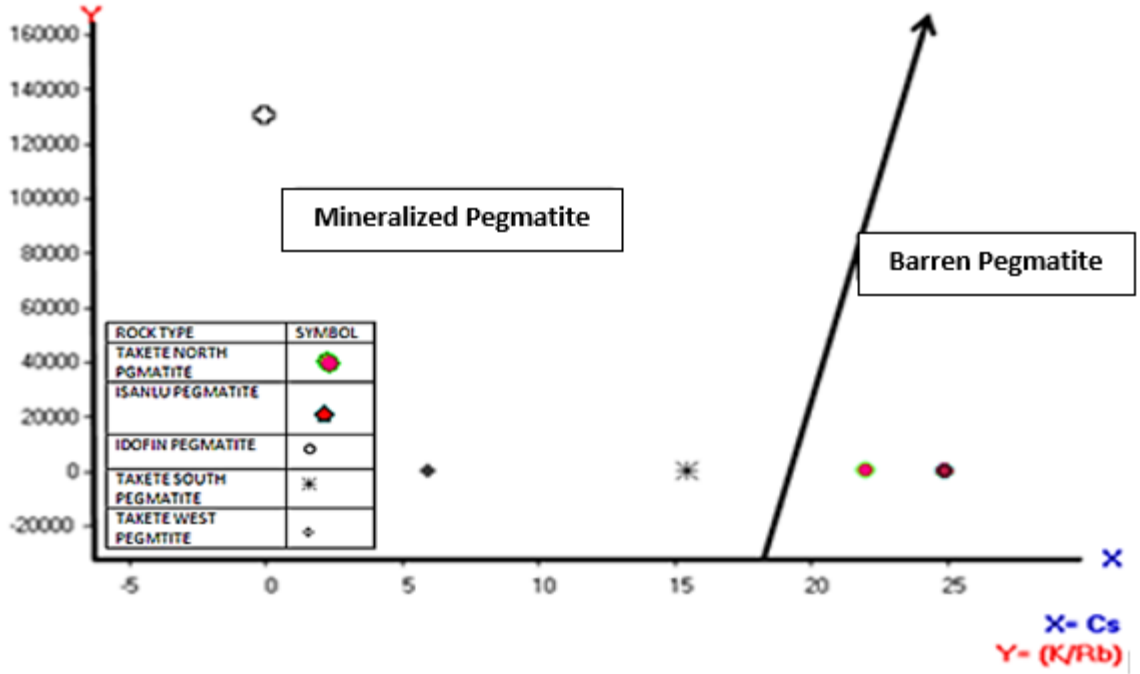


Figure 12: K/Rb versus Cs discrimination diagram showing the degree of fractionation and mineralisation of the pegmatites (adapted from Morteani et al., 2000)

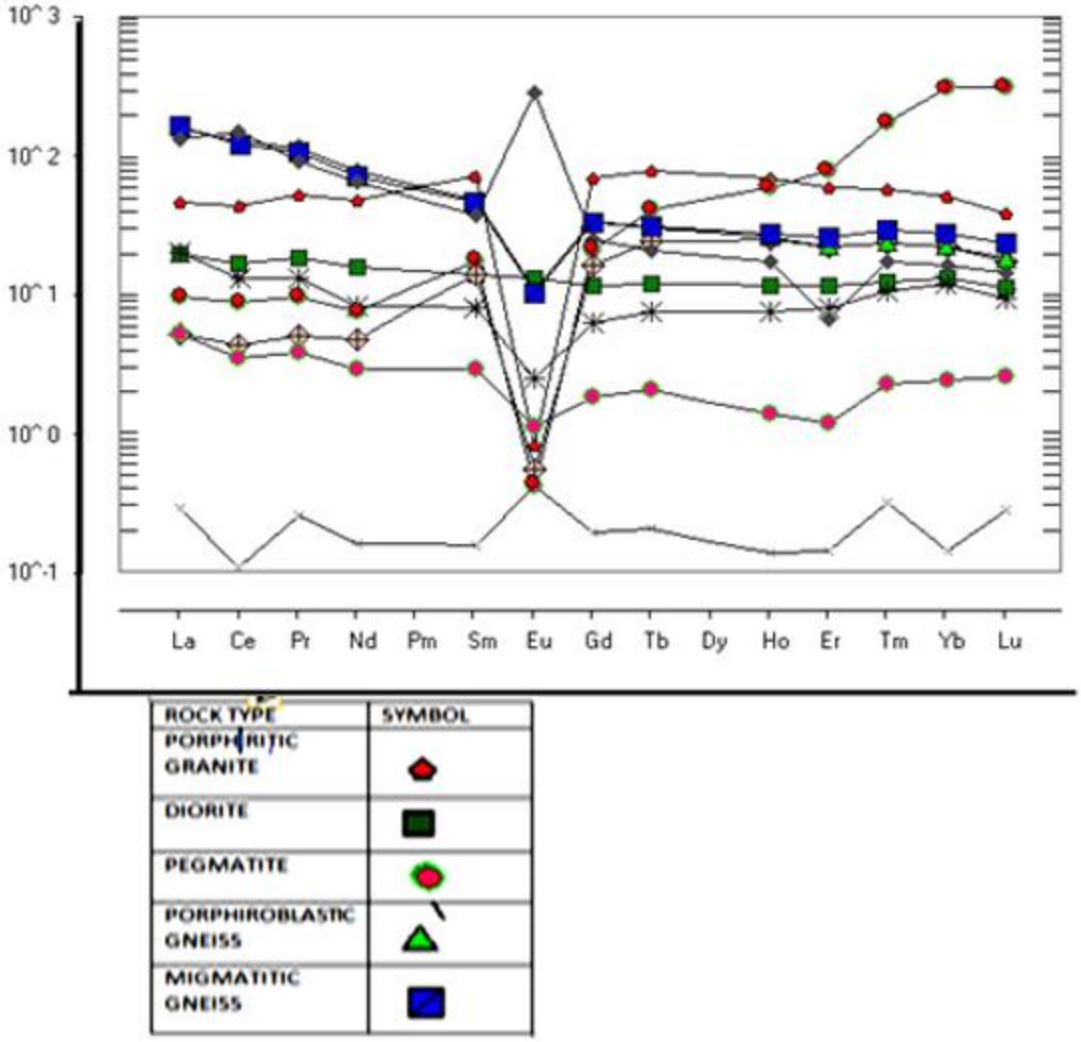


Figure 13: Chondrite normalized plot of the rare-earth elements (REE) for the rocks Isanlu area (Nakamura, 1974)

CONCLUSION

The study area is underlain by various lithologic units including Migmatitic Gneiss, Augen Gneiss, Banded Iron Formation (BIF), Quartzite, Muscovite Biotite Schist, Diorite, Coarse-grained Granites, Pegmatites and Vein Quartz. Most of the foliated rocks in the study area are dominantly striking NE-SW direction and dipping Westerly with few easterly dips. This is consistent with the known structural grains in rocks of the Basement Complex of Nigeria. The dominant open joints directions are NNE-SSW with fewer subordinate discordant joints. Foliations, lineation, pinch and swell, joints, folds and faults are the common structures mapped within the study area.

The total magnetic Intensity map (TMI) derived from the aeromagnetic anomaly data depicts values that ranging between 52.5- 85.2. The map also shows prominent high magnetic anomaly (71.5nT- 84.0nT) in both elongated and circular shapes distributed around the south-eastern and north-eastern part of the study area. The trend of dominant veins and joints directions obtained from the Tilt Vertical Derivatives (TDR) map also displayed NE-SW trends with few WNW-ESE trends which is consistent with the structural trends obtained from the field data.

The geochemical general classification plots for the granitoids of the study area shows them having rhyolitic composition and the tectonic discrimination plot shows them having within plate origin except for porphyritic diorite having basaltic affinity and lies in the field of oceanic ridge granite. The results of geochemical classification of the igneous and metasedimentary rocks of the area also put the granitoids as having sedimentary precursor except for diorite and pegmatites which shows igneous affinity with contributions from sedimentary source during their prolonged fractionation.

The REE fractionation pattern revealed on the chondrite normalized plot shows slight or no enrichments in light rare earth elements (LREE) with pronounced negative Eu anomalies for granitoids of the study area, including the mineralized pegmatites which however exhibit sharp positive Eu anomaly. This suggests the dominance of plagioclase in the melt which played a major role during fractionation with little or no influence from subordinate hornblende present in the fractionating melt. The rare-metal pegmatites are chemically enriched in Eu, Rb, Cs and Ta. The barren pegmatites at the northern areas of Takete and Isanlu shows a progressive enrichment in HREE and exhibit the lowest Eu anomaly and characterized by low Eu, Rb, Cs, Ta and Nb but high Ba, Sr and K/Rb.

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Table 1: Major Element composition of some selected rock samples the study area (%)

Oxides	QS63	BIF2	OGP4	OGc13	OGc58	P5	P8	P22	P34	P52	P54	OGd6	SCm37	OPg39	GG49
Al_2O_3	1.63	3.72	13.75	12.7	14.05	15	18.74	14	14.57	10.6	14.6	14.27	13.82	13.6	15.8
BaO	0.01	0.01	0.01	0.01	0.12	0.01	0.01	0.01	0.01	0.01	0.03	0.01	0.27	0.04	0.07
CaO	3.07	0.57	0.76	0.31	14.34	0.67	0.13	0.34	0.27	0.2	1.07	13.44	2.24	1.09	5.66
Cr_2O_3	0.01	0.01	0.01	0.01	0.01	0.698	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.22
Fe_2O_3	0.01	67.36	2	1.66	5.4	7.1	1.29	1.55	1.13	0.76	2.16	12.61	4.83	2.97	11.17
K_2O	0.08	0.5	4.77	4.83	2.23	1.21	3.04	3.77	2.84	4.88	4.72	0.45	6.69	5.59	3.22
MgO	0.03	0.89	0.08	0.02	1.78	0.03	0.03	0.09	0.15	0.03	0.33	5.92	0.7	0.45	2.83
MnO	0.01	2.11	0.03	0.02	0.09	5.2	1.2	0.04	0.05	0.1	0.07	0.27	0.08	0.04	0.17
Na_2O	0.02	0.84	3.97	2.63	3.82	4.29	4.29	0.01	3.71	2.78	3.64	0.65	2.5	2.73	3.26
P_2O_5	0.01	1.06	0.01	0.01	0.28	0.01	0.01	0.01	0.02	0.06	0.06	0.07	0.47	0.11	0.78
SiO_2	92.84	73.21	73.6	42.8	57.95	61	68.86	79.2	77.75	81.03	72.09	48.56	67.14	74.59	58.36
SrO	0.01	0.83	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.03
TiO_2	0.01	1.42	0.04	1.23	0.65	4.72	0.01	1.23	0.4	0.01	0.65	0.89	0.01	0.2	2.46
TOTAL	98.42	100.26	99.45	98.2	100.75	100.25	99.32	100	101.66	100.56	98.52	98.31	98.77	101.56	99.99

Table 2: Trace Elements composition of some selected rock samples the study area (ppm)

Elements	QS63	BIF2	OGP4	OGc13	OGc58	P5	P8	P22	P34	P52	P54	OGd6	SCm37	OPg39	GG49
Ba	23.7	6.89	12.1	31.1	521.7	27.05	13.3	51.11	52.7	77.2	304.1	54.5	0.27	394.3	0.07
Cr	12	0.83	25	38	128.4	0.689	18	25	24	12	110.6	115	0.01	25	0.01
Cs	14	0.73	6.2	4.32	0.76	20	22.03	7.8	24.89	15.49	21.45	3.14	1.31	8.34	2.42
Ga	60	392	29.3	25.8	20	34	59	24	64.3	21.3	24.80	18.9	21.1	17.3	24.8
Gd	23.7	23	17.68	4.17	16.83	5.9	5.42	5.6	0.47	1.6	8.48	3	20.87	8.76	15.76
Hf	56.67	1.02	6.5	8.2	8.9	4	1.1	9.8	0.5	0.7	4.9	2	39.31	7.6	11.8
Nb	16	24.1	1.37	90.7	42.1	10.5	25.7	0.371	103.4	58.5	44.5	51.80	39	21.3	52.8
Rb	784	8.49	384	405.5	103.9	34	784	45.9	755.6	616.8	419.5	18.5	267.4	300.9	225.8
Sr	2.4	91.8	5.2	3.7	3.3	23	11.3	12	7.4	53.2	6.5	213.8	223	42.2	279.6
Sn	34.6	2.09	6	7	14	3.8	99	42.8	71	5	12	13	14	8	12
Ta	2.4	12.5	4.6	18.5	3.3	35	1.23	4.6	47.6	53.2	6.5	19.83	3.3	15.6	2.5
Th	45	91.8	53.3	35.62	54.68	2.42	2.34	53.3	1.2	45.67	31.09	2.7	54.68	25.65	44.65
U	4.9	3.7	22.81	14.88	9.23	3.12	12.4	22.81	0.58	15.26	20.62	1.27	9.23	6.23	5.07
V	9	8.9	10	8	72	10	9	10	10	10	12	282	72	23	154
W	1	3	1	8	7	1	6	1	6	1		282	5	1	3
Y	100.4	9	111.1	31	43	94.7	100	111.1	3.1	19	57	22.1	132	48..9	56
Zr	8.9	20	117	134	34.56	10	0.048	117	7	15	145	57	34	262	67

Table 3: Rear Earth elements composition of some selected rock samples in the study area (ppm)

Elements	QS63	BIF2	OGP4	OGc13	OGc58	P5	P8	P22	P34	P52	P54	OGd6	SCm37	OPg39	GG49
Ce	12	1.9	39.5	4	521.7	8	8	12	3.32	12	110.6	15.3	417.7	12	0.07
Dy	45	0.45	24.23	8.88	24.4	12.6	17.92	23.4	0.54	2.66	9.36	3.66	22.1	8.84	13.29
Er	4.6	0.83	12.25	4.65	14.23	12.4	16.27	4.6	0.25	1.64	5.37	2.37	12.68	4.58	6.49
Eu	0.6	0.67	0.06	0.04	2.07	0.08	0.03	0.08	0.08	0.18	0.73	0.93	4.08	0.08	3.75
Ho	78	2.3	4.96	1.8	5.12	5.6	4.23	7.5	0.1	0.54	1.97	0.85	4.39	1.87	2.48
La	76.9	9.51	15.8	1.8	63.1	5.9	3.3	34	1.8	6.8	55	6.7	138.7	54.4	116.2
Lu	34.56	4.95	1.37	0.6	1.92	10.5	11.07	12	0.09	0.33	0.83	0.4	2.15	0.64	0.89
Nd	23	23.4	29.5	3	63.7	12	4.7	23	1.8	5.2	44	9.9	127.9	48.1	109
Pr	26	31.6	6.14	0.58	15.82	34	1.12	13	0.44	1.51	12.29	2.12	35.47	13.16	29
Sm	6.7	12.8	13.8	6.7	16.8	9	3.28	2.65	15	1.5	8.68	2.6	0.54	8.83	20.39
Tb	3.9	4.3	3.79	1.18	3.64	1.98	4.5	3.79	0.1	0.37	1.51	0.58	3.84	1.47	2.47
Tm	1.63	0.63	1.76	0.72	2.23	5.38	0.9	1.76	0.07	0.33	0.38	0.92	2.23	0.73	0.98
Yb	100.4	13.13	10.44	4.64	4.63	63.88	64.3	10.44	0.5	2.45	5.74	2.69	3.64	4.56	45