International Research Journal of Natural Sciences
Vol.8, No.2, pp.34-51, July 2020
Published by ***ECRTD-UK***
Print ISSN: ISSN 2053-4108(Print)
Online ISSN: ISSN 2053-4116(Online)

PETROGRAPHY, GEOCHEMISTRY AND MINERALISATION POTENTIAL OF THE PEGMATITES OF JANJALA AREA, NORTH CENTRAL NIGERIA

I.Y. Tanko[1] B.S Jatau[2] and H.O. Usman[3]
Department of Geology and Mining, Nasarawa State University Keffi, Nigeria[1,2 and 3]
Corresponding author: Tanko, I.Y[1*] e-mail: iyantanko2014@gmail.com; phone: 234o8164731237

ABSTRACT: *The petrographic, geochemical and mineralogical investigations of the pegmatites of Janjala area, North Central Nigeria was carried out with the aim of understanding its mineralization potential.* *Petrographic studies were conducted in the petrographic laboratory of the Department of Geology and Mining Nasarawa State University Keffi, while the geochemical analysis was carried out using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) techniques in the ACME laboratory limited, Vancouver Canada and NGSA laboratory Kaduna, Nigeria using XRF techniques. The seven (7) lithological units identified in the area consist of the biotite schist, muscovite schist, fine grained muscovite granite, medium grained biotite granite, medium grained granite, porphyritic granite and pegmatites. All the pegmatites are uncomformably emplaced and restricted to the biotite schist unit in the area around Janjala and Mahanga villages. Petrographic studies reveal the major mineral as quartz, K-feldspar, plagioclase, muscovite; while accessory minerals comprise of lepidolite, beryl, clevelandite, sericite, sphene, tourmaline and zircon. Major oxides and trace element contents indicate high fractionation and mineralization potential based on the variation plot of K_2O vs Na_2O, the relatively high values of Rb, Cs,Ta, Sn Nb, the K/Rb vs Rb and K/Rb vs Cs ratios which revealed that the pegmatites are relatively mineralized. Generally, the pegmatites in the Janjala area favourably compared well with other relatively mineralized rare-metal pegmatites of the North Central Nigeria, such as Wamba, Nasarawa and Keffi pegmatites.*

KEYWORDS: Pegmatite, granite, petrography, geochemistry and mineralization

INTRODUCTION

Pegmatites, the host rocks of trace and rare elements like Sn, W, Nb, U, Th, Li, Be, Ta, Cs, Rb and Ce, also contain a wide variety of exotic minerals like topaz, tourmaline and beryl. For example, in 1984, the Tanco pegmatite field of Manitoba, Canada supplied over 70% of the world's Ta_2O_5 concentrate and had pre-production reserves of 1.9 million tons of 0.216% Ta_2O_5, 6.6 tons of 2.7% Li_2O, 0.3 million tons at 23.3% Cs_2O and 0.8 million tons of 0.2% BeO (Crouse *et al*., 1984). The Bikita pegmatite of Zimbabwe is one of the world's largest lithium deposits with an estimated reserve of 30,000 tons of 4.2% Li_2O and besides lithium has yielded Be, Cs, Sn, Ta, Nb and feldspars (Evans and Pisarevsky, 2008). Keffi pegmatites of North Central Nigeria on the basis of field, petrographic and geochemical investigations have revealed potentials for gemstones (tourmaline, corundum and or beryl) and rare metal ores of (Sn, Nb and Ta) mineralisation. Hence

International Research Journal of Natural Sciences
Vol.8, No.2, pp.34-51, July 2020
Published by ***ECRTD-UK***
Print ISSN: ISSN 2053-4108(Print)
Online ISSN: ISSN 2053-4116(Online)

pegmatites are of great economic value and studies of their mineral compositions provide insight into their economic potential.

The usefulness of petrographic and geochemical studies (major, trace element and REE analyses) in resolving problems in pegmatite geology have been demonstrated in several studies (for example, Ginsburg *et al.*, 1979; Cerny, 1982a; 1982b; Ferreira, 1984; Crouse *et al*., 1984; Cerny, 1982a; Thomas and Spooner, 1988; Cerny, 1991a; London, 1992; among others). The Tanco pegmatite at Bernic lake in the Canadian Shield of southeastern Manitoba, for instance, experienced tremendous development in 1967as a result of the various trace element and REE distribution studies carried out in the area. Cerny (1991a) used Rb vs Cs and K/Rb vs K/Tl ratio plots for the main types of Tanco micas to identify nine pegmatite zones and their associated most important major and minor element contents. This enabled the mineralised zones within the pegmatite veins to be identified and made it possible to distinguish the mineralised veins from the barren ones.

Therefore, detailed petrolographic, geochemical and mineralization studies will enable a systematic investigation of the Janjala pegmatites and the adjoining granites with the view of characterising them and understanding their economic mineral potential. The studies will also provide guides for fruitful exploitation of the pegmatites and serve as model for the exploitation of pegmatite veins in similar geologic settings.

Geological Setting/Regional Geology
The Nigerian basement complex forms part of the Pan African mobile belt and lies between the West African and Congo Cratons and south of the Tuareg shield (Black, 1980; Burke and Dewey, 1972; Caby *et al*., 1981 (Figure 2)

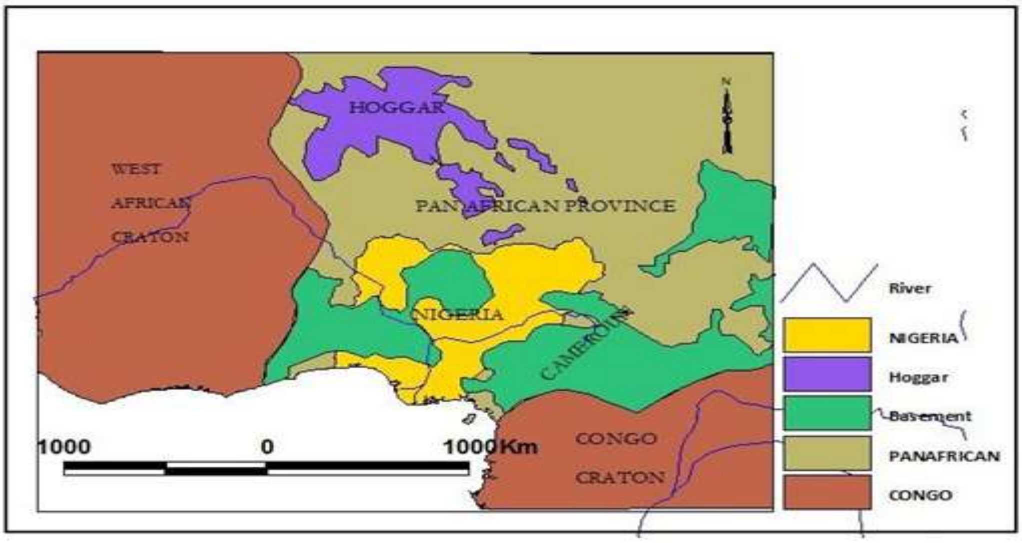


Figure 1: Location of the Nigeria sector of the Pan-African province of West

Africa (modified after Turner, 1983

The Pan African mobile belt believed to have evolved from the collision between the passive continental margin of the West African craton and the active continental margin of the Tuareg shield about 600 Ma ago (Burke and Dewey, 1972; Caby *et al*., 1981) experienced deformation, thermal reactivation, metamorphism and emplacement of large volume of granitoids typical of a Himalayan-type orogenesis during the Pan African thermo tectonic event (600 ± 150 Ma) (Dada, 2006).
The Nigerian Basement rocks have experienced at least four major orogenic cycles of deformation, metamorphism and remobilisation corresponding to the Liberian (2,700 Ma), the Eburnean (2,000 Ma), the Kibaran (1,100 Ma) and the Pan African Cycles (600 ± 150 Ma) (McCurry, 1976; Rahaman, 1973; Wright, 1976). The first three cycles of deformation are characterised by isoclinal folding accompanied by regional metamorphism and followed by extensive migmatisation, whilst the last cycle was characterised by deformation, metamorphism and granitisation. Within the basement complex of Nigeria, four major lithotectonic and geochronological units are distinguishable, namely: migmatite-gneiss complex of Archaean to Proterozoic age, the schist belt (Metavolcano sedimentary rocks) of late Proterozoic age, the Older granites or Pan African Granitoids of Paleozoic age and its associated pegmatites being the last stages of the granite emplacement and the undeformed felsic and mafic dykes of late Paleozoic.

METHODOLOGY

The area was mapped in two phases. The first phase was the reconnaissance survey carried out to familiarize with the terrain. During this phase, few samples were taken; routes and access roads were identified. The second phase entails detailed mapping where systematic investigation was carried out and oriented samples were collected at 2-3m intervals across the veins and field measurements of the dimension of outcrops and lineaments were taken.

Samples of pegmatites and host rocks (granites and schists) were collected in an oriented manner across the pegmatites into the host rocks. Samples were collected both at the surface and at some depth to ensure samples are fresh and representative.

A total of forty nine (49) whole rock samples were collected, out of which 33 were selected for petrography at the Laboratory of Nasarawa State University Keffi, Nigeria) and geochemical analyses (ACME laboratory Vancouver, Canada and Nigerian Geological Survey Agency (NGSA) laboratory Kaduna, Nigeria. The fifteen (15) whole rock samples of pegmatites selected for geochemical analysis were composited. Composite samples were obtained by mixing and blending all the whole rock rock samples collected from each pegmatite and ground to powder. The treated whole rock samples were digested and analysed for major, trace and rare earth element (REE).

Geology of the study area

Senven (7) lithological units were identified in the area which consist of biotite schist, muscovite schist, fine grained muscovite granite, medium grained biotite granite, medium grained granite, porphyritic granite and the pegmatites. The schists are of two types; the biotite schist and the muscovite schist. The predominant unit is the biotite schist which constitutes about 50%, whilst the muscovite schist covering the central part of the area constitutes about 10%. The granites and the associated pegmatites intrude the schist of Janjala area. The distribution of granite and associated pegmatites appears to dominate the south east and central parts of the mapped area and constitute about 40% (figure. 2). The main structural features in the area are the tectonic foliations, joints anf fractures mostly trending in the NE-SW and NW-SE directions (figures. 4,11 &13), metamorphism, fractures and joints (figs 10 &12) mostly believed to have been reactivated or formed during the Pan African tectonic events (600±150 Ma) (Dada, 2006).

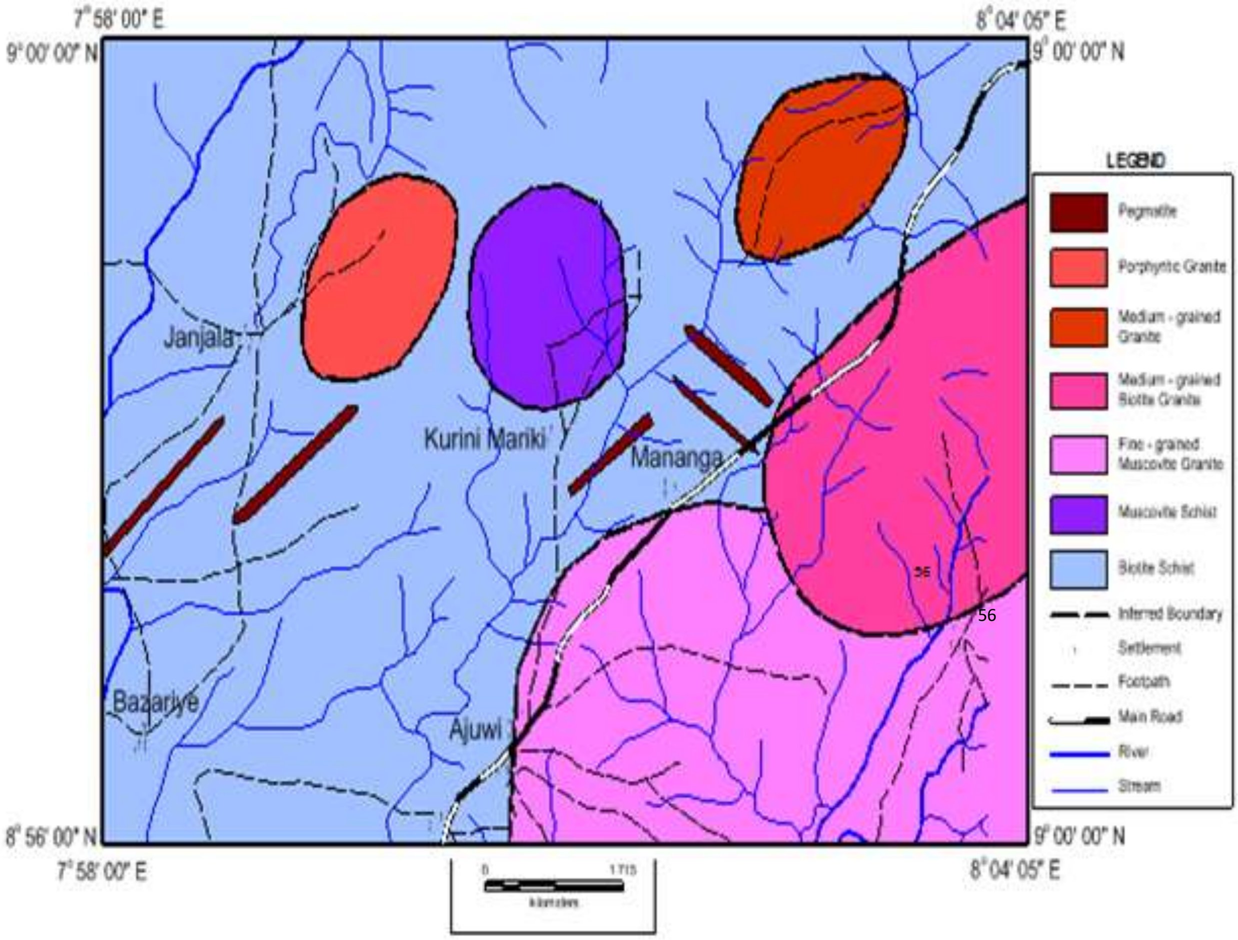


Figure 2: Geological map of the study area

Rocks of the Study Area (Pegmatites, Granites and Schists)

The field photographs of the pegmatites, granites and Schists and the rose diagrams of joints in the rocks

Figure 3: Field photograph of Janjala pegmatite 1(JP1)

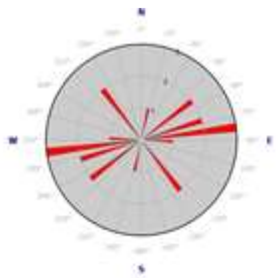


Figure 4: Rose diagram of joints of pegmatites

Figure 5: Field photograph of porphyritic granite7 (Gr7))

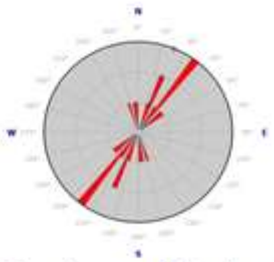


Figure 6: Rose diagram of joints in granites

Figure 7: Field photograph of muscovite shist10 (Sc10)

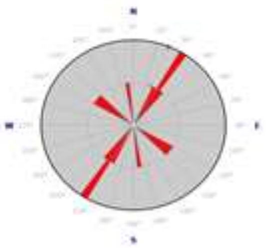


Figure 8: Rose diagram of joints in schists

The field features of pegmatites and associated rocks in Janjala area presented in (tables 1 and 2).**Table 1: Name, Location and other Field Features of Pegmatites of Janjala area**

Rock type Name		Location Identity	Orientation	Dimension		Host Rock
				Length	Thickness	
Pegmatite	Janjala Pegmatite 1(JP1)	N8^0 58′07.5″ $7^0$58′ 29.2 ″	045/56^0SE	600m	4m	Biotite schist
	Janajala pegmatite 2(JP2)	N8^0 58′02.5″ 7^0 40′02.2″	047/50^0NE	1km	3m	Biotite Schist
	Mahanga pegmatite3(MP3)	N8^0 58′04.5″ $8^0$01′ 26.2″	050/51N^{0}E	120m	4m	Biotite schist
	Mahanga pegmatite 4(MP4)	N8^0 58 ′10.5″ $8^0$02′05.2″	120/53^0S W	750m	6m	Biotite Schist
	Mahanga pegmatite5(MP5)	N8^0 58′26.5″ $8^0$02′03.2″	123/45^0NE	400m	2m	Biotite Schist

Rock Type Name		Locality Name	Location Identity
Associated Rocks	Medium Grained Biotite Granite	Gr6	N 08°58′07.1″ and E 008° 03′25.8″
	Porphyritic Granite	Gr7	N 08°59′09.6″ and E 008° 00′06.7″
	Medium grained granite	Gr8	N 08°59′30.1″ and E 008° 02′51.8″
	Fine grained muscovite granite	Gr9	N 08°57′21.9″ and E 008° 03′32.1″
	Muscovite Schist	Sc10	N 08°45′11.3″ and E 008° 01′25.3″
	Biotite Schist	Sc11	N 08°54′16.0″ and E 007° 58′56.0″

Petrography

This section discusses the textures, mineral assemblage and mineral composition of the pegmatites and associated rocks. The petrographic description of the pegmatites, granites and schists is presented in figure (9)

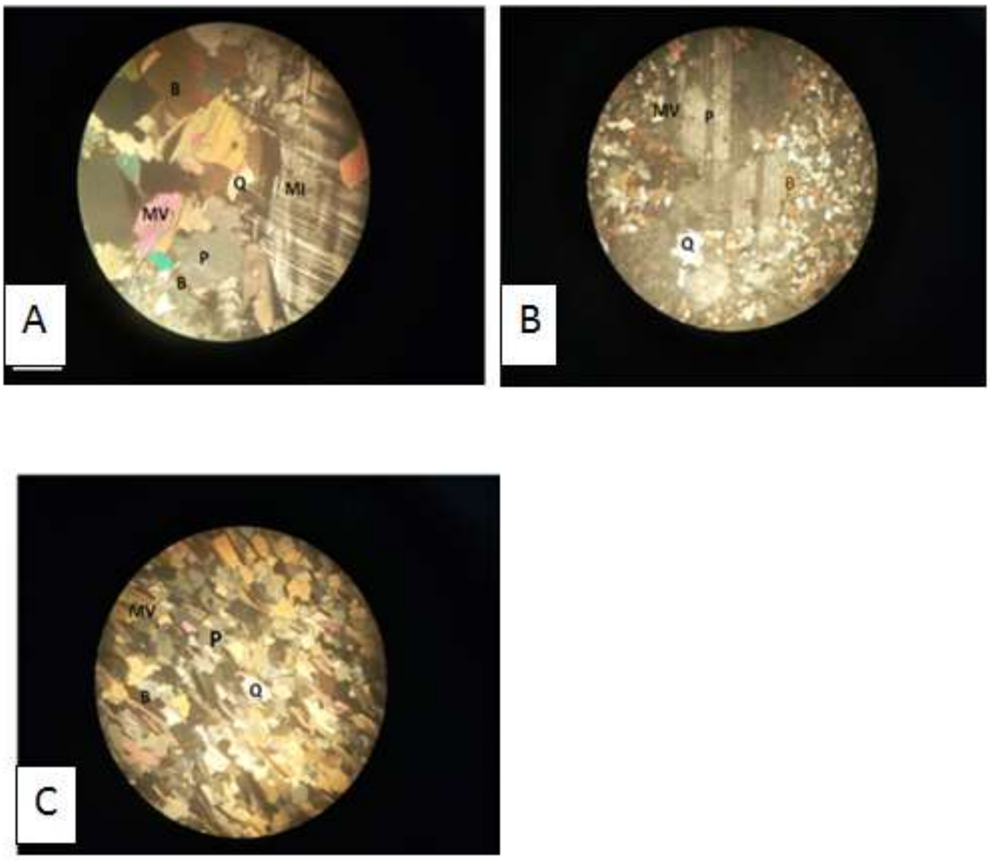


Figure 9: Photomicrographs of some selected pegmatite, granite and schist of Janjala area: (A) Janjala pegmatite pegmatite1 (JP1); (B) Porphyritic Granite 7 (Gr7); and (C) Biotite Schist (Sc11)

The summary of petrographic investigation of the pegmatites and associated rocks are presented in (tables 3 and 4).

Table 3: Summary of mineral composition of the pegmatites of Janjala area

Minerals	Janjala Pegmatite1(JP1)	Janjala Pegmatite 2(JP2)	Mahanga Pegmatite3(MP3)	Mahanga Pegmatite4(MP4)	Mahanga Pegmatite 5(MP5)
Rock forming Minerals (Vol.%)					
Alkali feldspar	15± 5	20 ± 5	22 ± 5	22 ± 5	25 ± 3
Plagioclase	20 ± 5	20± 5	15 ± 5	20 ± 5	21± 5
Quartz	30 ± 5	25 ± 5	10± 5	20± 5	23 ± 3
Biotite	20 ± 2	15 ±5	15 ± 1	10 ± 1	13 ±5
Chlorite	0-2	6±2	3 ± 2	3 ± 2	0-2
Muscovite	16± 10	15 ±5	5 ± 2	5 ± 2	16 ±3
Sericite	0-3	7 ± 3	15 ± 10	15 ± 10	5 ± 2
Hornblende	0-4	8± 3	0-2	0-4	1-3
	-	-	0- 2	0-2	0-3

Accessory Minerals (vol. %)					
Beryl	-	0-1	1.0	0-2	-
Lepidolite	0-3	-	0-2	-	0-4
Clevelandite	0-4	0-10	18 ± 8	0-10	0-10
Tourmaline	3 ± 2	8 ± 3	6± 2	0-4	0-8
Garnet	2 ± 1	4 ± 2	3± 2	4 ± 2	4 ± 2
Sphene	-	4 ± 1	1-3	4 ± 1	4 ± 1
Zircon	-	-	-	-	-

Table 4: Summary of mineral Composition of the host rocks (granite and schist) of Janjala area

Minerals	Granite 6 (Gr6)	Granite 7(Gr7)	Granite 8(Gr8)	Granite 9(Gr9)	Schist10 (SC10)	Schist 11(Sc11)
Rock forming Minerals (Vol.%)						
Alkali	-		22 ± 5	-	-	
feldspar	20 ± 5		10 ± 5	-	10 ± 5	10 ± 5
Plagioclase	20 ± 5		25 ± 5	20 ± 5	20 ± 5	20 ± 5
Quartz	10 ± 2		2 ± 1	15 ± 10	10 ± 2	10 ± 5
Biotite	-		3 ± 2	-	-	-
Chlorite	-		15 ± 10	-	-	-
Muscovite	-		15 ± 10	-	-	-
Sericite	-		0-2	-	3 ± 2	-
Hornblende	20 ± 5		15	10 ± 5	10 ± 5	-
Accessory Minerals (vol. %)						
Apatite	-	-	1.0	-	-	-
Beryl	-	-	0-2	-	-	-
Lepidolite	-	0-10	18 ± 8	-	-	-
Clevelandite	-	?	?	?	-	-
Tourmaline	3 ± 2	4 ± 2	3± 2	0-2	-	0-1
Garnet	2 ± 1	3 ± 2	0-2	0-4	0-2	2 ± 1
Sphene	-	-	-	-	-	-
Zircon	-	-	1-2	-	1-4	0-3

Geochemistry

Geochemical investigations of pegmatites and associated rocks were carried out to determine major, trace and Rare Earth Element (REE) variations. This is to understand the evolution (i.e. relationships with the surrounding rocks) of the pegmatites, and tectonic environments classification of the pegmatites and associated granitoids in Janjala area whose most mineralogical characteristics were obliterated and could not be identify under the microscope. The geochemical data of oxides, trace and Rare Earth Element REE are presented in tables (5, 6 and 7).

Table5: Averages of major oxides and ratios of whole rock of pegmatites in Janjala area

Sample ID	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	Cr_2O_5
JK1	71.75	18.41	1.60	0.14	0.60	4.25	3.08	0.04	0.57	0.02	0.004
JK2	56.92	16.54	1.42	0.14	1.59	4.25	3.94	0.02	1.31	0.62	0.001
JK3	74.29	15.34	3.54	0.42	3.01	0.59	6.20	0.25	0.07	0.11	0.010
JK4	70.25	15.89	3.04	0.47	1.90	1.06	5.15	0.03	1.09	0.21	0.002
JK5	63.47	17.42	1.05	0.61	0.13	7.30	3.15	0.22	0.41	0.17	0.010
Gr6	68.19	16.53	1.67	0.50	1.34	0.66	6.10	0.25	0.20	0.02	0.006
Gr7	70.22	15.44	1.89	0.42	1.21	1.04	8.21	0.13	0.08	0.05	0.003
Gr8	71.23	15.45	1.92	0.05	0.42	0.79	8.99	0.02	0.02	0.13	0.002
Gr9	66.27	15.28	3.35	0.89	4.04	0.29	9.41	0.59	0.40	0.04	0.003
SC10	64.79	14.96	5.01	1.54	3.71	0.23	9.63	0.77	0.86	0.02	0.012
SC11	62.98	16.00	6.32	2.23	1.50	0.72	10.30	0.45	0.57	0.14	0.013

(wt%)

Table 5: Continued

NaO_2/K_2O	K_2O/Al_2O3	Na_2O/Al_2O_3	Al_2O_3/Na_2O+K_2O	$Al_2O_3/CaO+Na_2O_3+K2O$
1.38	0.17	0.23	2.51	2.32
1.08	0.24	0.26	2.02	1.69
0.10	0.40	0.04	2.26	1.57
0.21	0.32	0.07	2.56	1.96
2.32	0.18	0.42	1.67	1.65
0.11	0.37	0.04	2.45	2.04
0.13	0.53	0.07	1.67	1.48
0.09	0.58	0.05	1.58	1.51
0.03	0.62	0.02	1.58	1.11
0.02	0.64	0.02	1.52	1.10
0.07	0.64	0.05	1.45	1.28

The major element contents of whole rock samples of Janjala pegmatites has ranges of SiO_2 74.29-56.92%, and in the associated rocks 71.23-62.98% and the other oxides ranges as Al_2O_3 18.41.01-14.96%, Fe_2O_3 6.32-1.05%, MgO 2.23-0.05%, CaO 4.04-0.13%, Na_2O 7.30-0.23%, K_2O 10.30-3.08%, TiO_2 0.77-0.02%, P_2O_5 1.31-0.02%, MnO 0.62-0.02% and Cr_2O_3 0.013-0.001%.

Table 6: Averages of trace elements and ratios of whole rock of pegmatite of Janjala in (ppm)

ID	Be	Cs	Ga	Hf	Nb	Rb	Sn	Ta	W	Tl	Li	B	Nb/Ta	K/Rb
JK1	15.03	1350.5	21.9	1.90	16.70	1038.76	64.0	41.90	3.40	0.40	1030.0	650..0	0.40	24.62
JK2	8.69	895.5	34.98	6.10	25.10	789.80	87.0	34.76	2.30	2.30	4300.0	766.0	0.72	41.42
JK3	7.01	502.2	45.86	4.70	36.85	700.80	1002	80.20	5.10	5.10	6200.76	2000.0	0.46	73.45
JK4	13.00	765.3	20.0	24.20	140.30	140.20	58.0	199.1	2.20	2.20	5400.0	2000.0	0.70	304.96
JK5	21.00	2300.2	30.0	7.70	83.80	2800.30	588.0	201.4	3.70	3.70	6300.0	1837.0	0.42	9.34
Gr6	4.65	10.93	37.0	4.92	7.90	305.84	12.0	0.48	0.20	0.20	123.0	11.25	16.46	165.58
Gr7	7.15	10.28	13.10	5.13	23.81	382.45	5.00	1.76	0.70	0.70	120.0	29.75	13.53	178.22
Gr8	7.00	11.1	36.53	12.25	146.11	411.14	54.10	13.10	0.92	0.92	324.0	3.75	11.15	181.53
Gr9	4.20	26.19	19.92	6.40	8.90	106.10	6.11	1.450	0.60	0.60	0.00	0.00	6.14	736.30
SC10	5.15	24.92	37.79	8.08	15.62	143.40	7.23	2.90	0.30	0.30	0.00	0.00	5.39	557.52
SC11	8.10	32.2	22.45	4.45	27.10	104.48	13.90	3.15	1.60	1.60	0.00	0.00	8.60	818.44

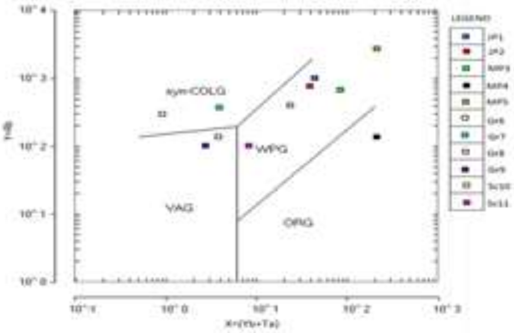
The trace elements range as Rb 2 800.30-104.48 ppm, Cs 2300.20 -10.28ppm, Li 6 300.00-0.00 ppm, Be 15.03 - 4.20 ppm, Ga 45.86 - 13.10 ppm, Hf 24.20 – 1.90 ppm, Nb146.11- 7.90 ppm, Sn 1002.0ppm, W 5.10-0.20 ppm, TI 5.10-0.20ppm, B 2000.00 -0.00ppm,.Ta 201.40-0.48ppm.

Table 7: Rare Earths Elements (REE) of the whole rock of pegmatites of Janjala

ID	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
JK1	5.76	8.50	2.41	5.60	0.82	0.46	2.14	0.34	2.06	0.06	2.05	3.00	0.67	1.02
JK2	1.70	5.10	0.70	2.04	1.03	0.02	1.11	0.68	2.50	0.17	0.99	0.93	2.39	0.38
JK3	4.11	7.90	1.63	6.1	1.34	0.60	1.62	0.11	2.10	0.72	1.02	1.10	1.03	0.10
JK4	21.1	37.40	4.27	17.38	3.03	0.27	2.32	0.34	2.20	0.55	1.09	0.5	1.98	0.35
JK5	18.98	37.30	5.00	14.8	3.02	0.23	1.71	0.20	1.02	0.82	0.35	0.72	0.91	0.01
Gr6	61.97	103.45	12.2	34.7	6.24	0.65	2.64	0.31	0.91	0.29	1.22	0.13	0.41	0.06
Gr7	27.69	47.68	5.97	11.7	6.10	0.74	5.00	0.61	5.03	0.81	2.05	0.40	2.00	0.12
Gr8	19.0	49.92	6.14	17.4	6.63	0.07	8.42	2.62	15.20	4.40	11.24	1.63	9.60	1.23
Gr9	26.95	60.15	66.19	23.1	5.06	1.65	4.16	0.89	3.80	0.82	1.82	1.05	1.25	0.10
SC10	41.0	76.13	8.40	41.0	6.00	2.12	4.77	0.26	2.83	1.40	1.76	0.32	0.82	0.22
SC11	31.6	68.55	8.20	30.5	8.84	2.71	7.10	2.01	8.00	0.93	4.08	0.27	4.80	0.61

Both the oxides , trace, and REE elements values compared favourably with Keffi pegmatites (Tanko, 2014) and other rare metal pegmatites field across Nigeria Akintola et al., 2012).

1. **Tectonic Classification and origin of pegmatites and associated rocks of Janjala area**
   The tectonic classification and origin of pegmatites and associated rocks of Janjala area are presented in figures 21,22,23 and 24 below.



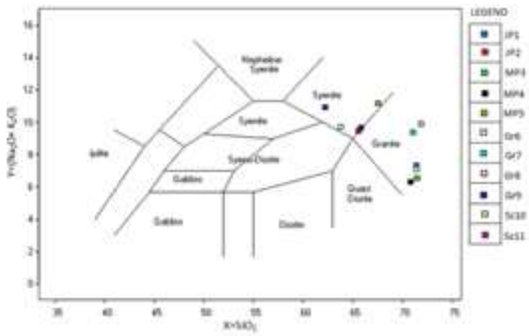
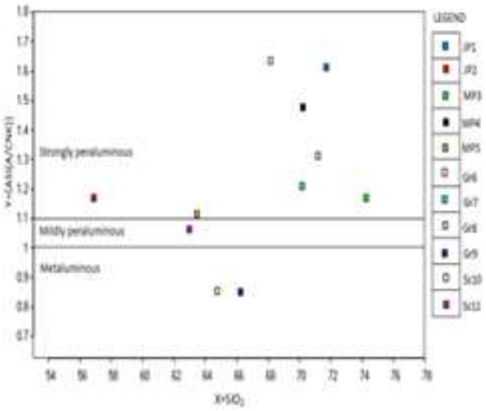


Figure 10: Plot of Rb vsYb + Ta (after Pearce et al., 1984) Figure 11: Plot of Na_2O+ K_2O vs Si_2O (after Cox- Bell-Pank,1979)



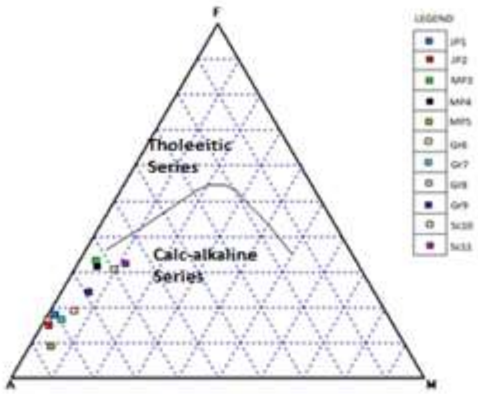
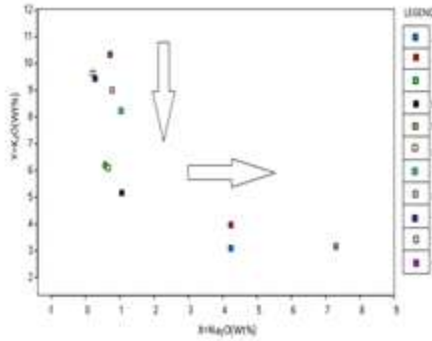


Figure 12: Plot of ASI/CNK vs Si_2O diagram (afterChappel and White 1974) Figure 13: Plot of AFM (after Irvine and Baragar, 1971)

Relationships between pegmatite and associated rocks of Janjala area

The relationship between pegmatites and associated rocks of Janjala area is presented in Figures 25 and 26 below.



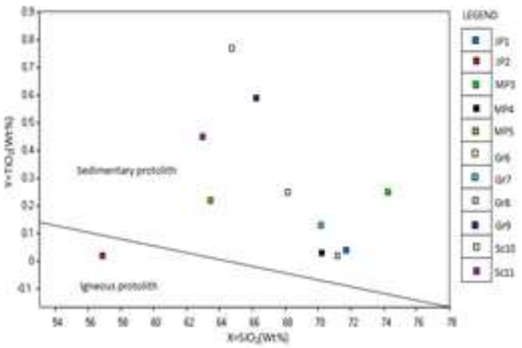
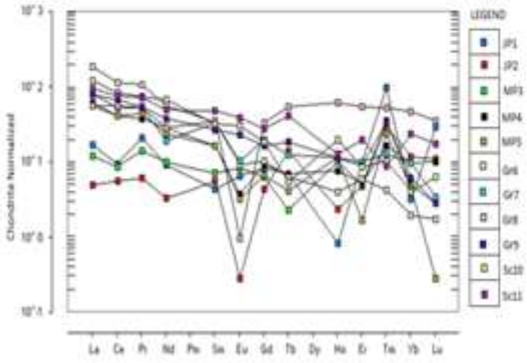


Figure 14: Plot of variation of K_2O vs Na_2O showing (after Chappell and White 1974)

Figure 15: Plot of TiO_2 + Si_2O

Rare Earth Elements (REE) content of pegmatites and associated rock of Janjala area

Figures 27 and 28 show the contents of pegmatite and associated rocks of Janjala area.



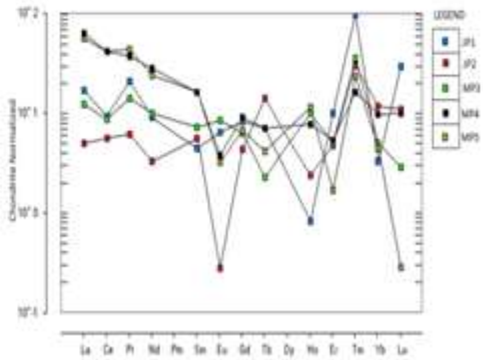


Figure 16: Plot of REE of pegmatites and associated rocks

Figure 17: Plot of REE of pegmatites

Mineralization potentials of the pegmatites of Janjala area

The mineralization potential of the pegmatites of Janjala area are shown in figures 29, 30 and 31.

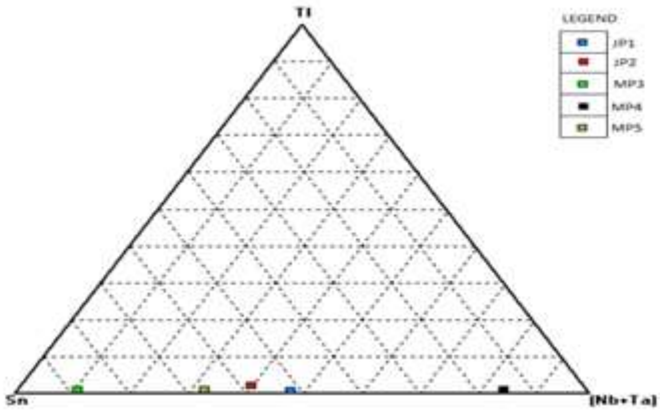
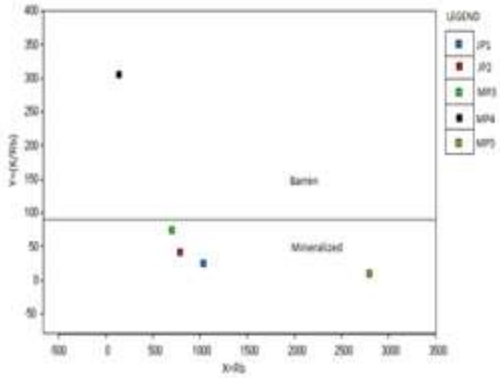


Figure 18: Plot of Ti-Sn-Nb+Ta of pegmatites of Janjala area (Adopted from Kuester,1990)



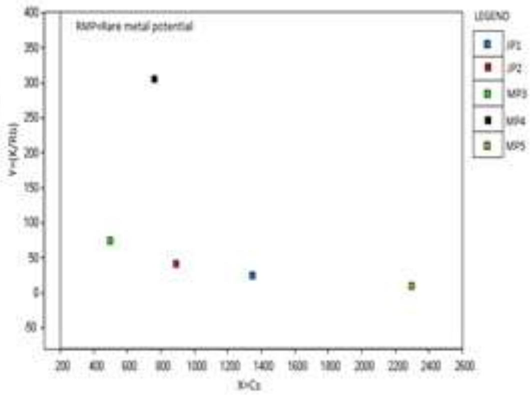


Figure 19: Plot of K/Rb vs Rb (after Staurov *et al.*, 1962)   Figure 20: Plot of K/Rb vs Cs (Adapted from Cerny,1982a

Table 8: Comparison of the mineralization of Wamba, Nasarawa, Keffi and Janjala (Present work)

S/N	Characteristics	Wamba Pegmatite (Kuster, 1990)	Nasarawa Pegmatite (Adekeye and Akintola, 2008)	Keffi Pegmatite (Tanko, 2014)	Janjala Pegmatite (Present Work)
1	Mineralisation potentials	-According to their rare alkali fractionation, Wamba pegmatites are members of rare metal class (Li-Cs-Ta). -They were shown to have Sn-Nb-Ta mineralisation. -In addition they contain garnet, tourmaline, and beryl.	- Classified the pegmatites as Li-Cs-Ta (LCT) of (Cerny, 1991). -Simple pegmatites consist of quartz, microcline, microperthite and minor plagioclase. Accessory minerals comprise of garnet, tourmaline, and magnetite. -Complex (mineralised) show pervasive albitisation, perthite crystal, quartz and ores of Nb-Ta-Sn-Li-Be.	Classified the pegmatites as LCT type of (Tank,2014) -Mineralsed pegmatites consist of quartz, microcline, plagioclase. Accessory minerals comprise of garnet, tourmaline,sericite, tourmaline. -Complex (mineralised) show pervasive alteration sericitization, and tourmalinization)	-Classified the pegmatites as LCT type -Mineralsed pegmatites which consist of quartz, k-feldspar, plagioclase. Accessory minerals comprise of Beryl, Lepidolite, Clevelandite, Tourmaline, Sphene -Complex (mineralised) show pervasive alteration sericitization, muscovitization and tourmalinization) -Potential for Nb,Ta,Sn mineralization

DISCUSSION

Classification and tectonic environments of the pegmatites and associated rocks of Janjala area

Following after the tectonic environment classification criteria of pegmatites and its associated granitic rocks and the realisation that genesis of most granitic rocks relate to different environments (Cerny, 1991b; Martin and De Vito, 2005; London, 2005) and different mineralisation is also related to different environments; that the relationships between Janjala pegmatites and its associated granitic rocks and their environments is considered necessary in understanding their mineralization potential. The plot of Rb vsYb + Ta (figure 11) and the plot of Na_2O+ K_2O vs Si_2O (figure 12) which show that majority of the samples plot in the Syn-Collisional Granite (SYN-COLG) and Within Plate Granite (WPG) field. Similarly the plot of ASI/CNK vs Si_2O (figure 23) shows that most of the Janjala pegmatites and the associated granitic rocks are strongly to mildly peraluminous. Also the AFM diagram show the rocks of Janjala fall in the calc-akaline series. All these are indications of the granitic and tectonic nature of the origin of both Janjala pegmatites and its associated granites. Furthermore, they suggest them belonging to the Older granite rock series associated with the syn- to late-Pan African magmatic activities as proposed by Kuster (1990) and Garba (2003).

Relationships and genesis of the pegmatite and the associated granites

The field proximity between the pegmatites, the granites and the schist and the mineralogical compositions is suggestive of a common genesis. Petrographically, predominance of major minerals; quartz, k-feldspar, plagioclase, muscovite and accessory minerals such as lepidolite, sericite, tourmaline , clelandite, beryl, zircon, sphene in both the pegmatites and associated granites are suggestive of common origin.

Dill (2015) noted that pegmatites are normally found in environments different from their places of origin and that they are often mobilised at depth and migrate into different environments. It may thus be concluded that the dry pegmatitic melt that form the pegmatites and their associated granitic rocks of Janjala area was generated from the metasedimentary rocks by remobilisation during anatexis at depths beneath their places of emplacement; and that the mobilised melt rose to shallower depths to intrude the overlying granites and schists.

From both oxides and trace element and the relationship between the pegmatites and associated rocks of Janjala area, the variation of K_2O vs Na_2O 3 and TiO_2 + Si_2O, it can be seen that there is a link between pegmatites and the associated rocks. The REE values in all the samples show light REE enriched fractionated abundance patterns. The degree of light REE enrichment increase in the order schist- granites- pegmaties (figures 16 and 17).The similarities in the patterns suggest linkages within the pegmatites and between the pegmatites and the associated rocks. The irregularities may imply a complicated evolutionary history. The REE abundance in the Janjala area both match closely with those in similar terrain of other North Central Nigeria.

Mineralization potential of the pegmatites

On the basis of field and petrographic observations the pegmatites of Janjala area have shown common features in (tables 1, 3 and figure 9). The major mineral contents of quartz, K-feldspar, plagioclase, muscovite and the accessory minerals such as lepidolite, tourmaline, sericite, lepidolite, zircon, clelandite; as well as the sericitization, muscovitization and lepidolization that chacterize the pegmatites indicate that most of the minerals were formed from secondary processes. These features suggest the pegmatites to be moderately evolved and mineralised. Comparably, these pegmatites correspond to the complex type (LCT) of the rare metal pegmatites and may be potential for both rare metal and gemstones mineralisation (Cerny, 1982a, 1982b; Cerny & Ercit, 2005).

From the plots of Ti-Sn-Nb+Ta of the pegmatites (figure 18) , K/Rb vs Rb (figure 19) and K/Rb vs Cs (figure 20), it suggest that the pegmatites of Janjala area are relatively rich in Sn, Ta and Nb. Furthermore, it is believed that extreme fractionation of lithophile element such as Rb and Cs is common geochemical feature of granitic pegmatites, especially the rare metal bearing types. Late-stage progressive fractional crystallization leads to decrease in K/Rb ratio implying metasomatism and invariably mineralization (Akitola et al. 2012). From table 8, the plot of Ti-Sn-Nb+Ta of pegmatites (figure 18), the plot of K/Rb vs Rb (figure 19) and Plot of K/Rb vs Cs (figure 20), it can be inferred that the Janjala pegmatites are relatively fractionated when compared with the rare-metal pegmatites. Also the degree of albitization revealed by the triangular Ti-Sn-(Nb+Ta) discriminate plot, the Janjala pegmatites which fall within the zone of albitization, indicating mineralization potential. Furthermore, from (table 8) the Janjala pegmatites are comparable to the rare-metal pegmatites of Wamba Pegmates (Kuster, 1990), Nasarawa pegmatites (Adekeye and Akintola, 2008) and Keffi pegmatites (Tanko, 2014) of the North Central Nigeria.

CONCLUSION

It is concluded from the field investigation that the six (6) lithological units identified in the area consist of the biotite schist, muscovite schist, fine grained muscovite granite, medium grained biotite granite, medium grained granite, porphyritic granite and the pegmatites. All the pegmatites are uncomformably emplaced and restricted to the biotite schist unit in the area around Janjala and Mahanga villages. Petrographic studies reveal the major mineral as quartz, k-feldspar, plagioclase, muscovite, whilst accessory mineral which comprise of lepidolite, beryl, clevelandite, sericite, sphene. tourmaline and zircon suggesting the pegmatites are relatively evolved and mineralized.

Geochemical determination of both oxides and trace contents indicate high fractionation and mineralization potential. Furthermore, the pegmatites of Janjala area compared favourably well with the other relatively mineralized rare-metal pegmatites of the North Central Nigeria such as Wamba pegmatites , Nasarawa pegmatites and Keffi pegmatites.

Acknowledgement
The authors wish to graciously acknowledge and appreciate the sponsors of this research work through the TETFUND Research Intervention Programme (2016), the management of Nasarawa State University, Keffi and ACME Laboratory Limited, Vancouver, Canada and NGSA laboratory Kaduna, Nigeria.

References

Akintola, A. I. Omosanya, K. O., Ajibade, O. M., Okunlola, O. A. and Kehinde-
Phillips, O. O. (2011), "Petrographic and Geochemical Evaluations of Rare Metal (Ta-Nb) Potentials of Precambrian Pegmatites of Awo Area Southwestern, Nigeria",

International Journal of Basic and Applied Sciences, IJBAS-IJENS, Vol. 11, No. 4, pp. 78 – 95.

Baker, D. R. (1998), "The Escape of Pegmatite Dikes from Granitic Plutons: Constraints from New

Models of Viscosity and Dike Propagation", *Can. Mineral*., Vol. 36, pp. 255 – 263.

Black, R. (1980), "Precambrian of West Africa", *Episodes*, No. 4, pp. 3 – 8.

Burke, K. C. and Dewey, J. F. (1972), "Orogeny in Africa." In: Dessauvagie, T.F.J. and Whiteman, A. J. (Eds.), *African Geology*, University of Ibadan Press, Ibadan, pp. 583 – 608.

Caby, R., Brand, J. M. L and Black, R. (1981), "Pan-African Ocean Closure and continental Collision in the HoggarIforas Segment, Central Sahara", in Precambrian Tectonics", Edited by a Kroner, *Elsevier Amsterdam*, pp 407 – 434.

Cerny, P. (1982a), Petrogenesis of Granitic Pegmatites, In Granitic

Pegmatites in Science and Industry, Mineralogical Association of Canada, Short Course Handbook, No. 8, pp. 405 – 461.

Cerny, P. (1982b), The Tanco Pegmatite at Bernic Lake, Southeastern Manitoba,Mineralogical Association of Canada, *Short Course Handbook* No. 8, Granitic Pegmatites in Science and Industry, pp. 527 – 543.

Cerny, P. (1991a), "Rare-Element Granitc Pegmatites, Part I: Anatomy and Internal Evolution of Pegmatite Deposits", *Geoscience Can.*, Vol. 18, pp. 49 – 67.

Cox, K. G. Bell, G. D. and Pankhurst, R. J. (1979), 'The Interpretation of Igneous Rocks, George, Allen and Unwen, London.

Chappel,B.W. and White,A.J.R.(1974).Two contrasting granite types.*Pacific Geology,8,173-174.*

Crouse, R. A., Cerny, P., Trueman, D. L., and Burt, R. O. (1984), "The Tanco Pegmatite, Southeastern

Manitoba", In CIM Special, *The Geologyof Industrial Minerals in Canada*, Vol. 29, pp. 169 – 176.

Dada, S. S. (2006), "Proterozoic Evolution of Nigeria", In: The Basement Complex of Nigeria and its Mineral Resources (Oshin O. ed.), *A Symposium organized to mark the 60th birthday of Prof. M. A. O. Rahaman, held at the Conference Centre, Obafemi AwolowoUniversity,Ile – Ife*, Nigeria, May 6th 2006, pp. 29 – 44.

Ferreira, K. J. (1984), The Mineralogy and Geochemistry of the Lower TancoPegmatite, Bernie Lake, Manitoba, M.Sc. Thesis, University of Manitoba,Winnipeg, Man, Canada.

Garba, I. (2003), "Geochemical discrimination of Newly Discovered Rare Metal Bearing and Barren Pegmatites in the Pan African 600 ± 150 Ma Basement of Northern Nigeria", *Applied Earth Science Transaction Institute of Mining and Metallurgy*, No. 13, Vol. 112, pp. 287 – 292.

Ginsburg, A. I., Timofeyev, I. N. and Feldman, L. G. (1979), *Principles of Geologyof the Granitic Pegmatites*, Nedra, Moscow, Russia, 296pp.

Irvine,T.N. and Baragar,W,R.A.(1971).A guide to the chemical classification of the common volcanic

rocks.*Canadian Journal Journal Earth Sciences,8,523-548.*

Jacobson, R. and Webb, J. S. (1946), "The Pegmatite of Central Nigeria", *Geological Survey of Nigeria Bulletin*, Vol. *17*, 61pp.

Jones, H. A. and Hockey, R. D. (1964), "The Geology of Part of South Western Nigeria", *Geol. Surv. Nigeria Bull.* No. 31, 101pp.

Kuster, D. (1990), “Rare-Metal Pegmatites of Wamba,Central Nigeria-their Formation in Relationship to Late Pan-African Granites”, *Mineral Deposita*, Vol. 25, pp. 25-33.

London, D. (2005), “Granitic Pegmatites, An Assessment of Current Concepts andDirections for the Future”, *Lithos*, Vol. 8, pp. 281 – 303.

London, D. (1992), “The Application of Experimental Petrology to the Genesis And Crystallisation of Granitic Pegmatites”, *Can. Mineral, Vol.* 30, pp. 499 – 540.

Martin, R. F. and De Vito, C. (2005), “The Patterns of Enrichment in FelsicPegmatites Ultimately Depend on Tectonic Setting”, *Can. Mineral*, Vol. 43, pp. 2027 – 2048.

McCurry, P. (1976), “The Geology of the Precambrian to Lower Paleozoic Rocks of Northern Nigeria-A Review”, *Geology of Nigeria.*, Elizabethan Publ. Co., Lagos, pp.15 – 40.

Pearce, J. A., Harris, N. B. W., Tindle, A. G. (1984), “Trace ElementDiscrimination Diagram for the Tectonic Interpretation of Granitic Rocks”, *Journal of Petrology*, Vol. 22, pp. 956-983.

Rahaman, M. A. (1988), “Recent Advances in the Study of the Basement Complex of Nigeria”, Precambrian Geol. Nigeria, Geol. Surv. Nig. Pub., pp. 324 – 327.

Staurove, O. D., Stolyarov, L. S. and Isochewa, E. I. (1969), “Geochemistry and Origin of Verkh Iset Granitoid Massif in Central Ural”, Geochem., Intern., Vol. 6, pp. 1138 – 1146.

Tanko I.Y (2014) Petrogenesis and mineralization of the pegmatites of Keffi Area, North Central Nigeria, An

Unpublished thesis of the University of Mines and Technology

Tarkwa Ghana,Department of Geological Engineering.

Thomas, A. V. and Spooner, E. T. C. (1988), “Occurrence, Petrology and FluidInclusion Characteristics of Tantalum Mineralisation in the Tanco Granitic Pegmatite, S. E. Manitoba”, Granite-Related Mineral Deposits, *In CIM Special*, Vol. 39, pp. 208-222.

Wright, J. B. (1976), “Fracture Systems in Nigeria and Initiation of Fracture Zones in the South Atlantic”, *Tectonophysics*, Vol. 34, pp. 743 – 747.