Geochemistry, classification characteristics and mineralization potential of Pegmatites from Oke Ode, Kwara-State, Northeastern, Nigeria: implications for provenance and weathering history

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Abstract

Geochemical analysis of eight (8) representative pegmatite samples reveals high silica (SiO_2) 56-62.05 wt % and alumina (Al_2O_3) 6.80-8.39 wt % contents. The alumina (Al_2O_3) is greater than the alkali Na_2O + K_2O +CaO in all the rock samples by values ranging between 0.79 and 1.25wt % implying that the rocks are peraluminous. MgO (0.00-0.00wt%), CaO (1.65-1.86wt %) and Fe_2O_3 (2.89-3.86 wt %) have low contents. Paleo-weathering plot reveals a moderate humid climatic condition and the mean values of CIA (45.15), CIW (81.00), PIA (11.32) and indicates low to high chemical weathering in the source area. Rocks that are characterized by low Mg, Ca, and Fe as well as low ratio of Na_2O/K_2O are termed "fertile" and peraluminous. A plot of Al_2O_3/ (CaO + Na_2O + K_2O) versus Al_2O_3/Na_2O + K_2O shows and confirms the peraluminous character of the pegmatite from Oke-Ode. Rocks that are fertile and peraluminous are rich in albite ($NaAlSi_3O_8$), potassium feldspar ($KAlSi_3O_8$) and quartz (SiO_2). The abundance of feldspar and mica are geochemical indicators for Sn-Ta mineralization. The plotting of samples in both the tholeiitic and calc-alkaline fields shows that the magma from which the pegmatite was formed was not totally restricted in occurrence only to subduction-related environment but also from the oceanic crust of calc-alkaline environments. The trace elements such as of As, Mo, Rb and Zn with an average of 5.33ppm, 28.00ppm, 145.22ppm, and 24.89ppm, respectively shows that they are above the abundance level in common rocks. This indicates that the As, Mo, Rb, and Zn are abundant in all the samples of the study area.

Keywords: Geochemistry, Mineralization, Provenance, Weathering history, Pegmatite, Oke-Ode, Nigeria

1. Introduction

Nigeria possesses a very large pegmatite environment. The pegmatites are widely distributed with a marked concentration of mineralized pegmatites in a broad belt, which extends from Ago-Iwoye in the southwest to Bauchi in the northeast, an air distance of more than 400kilometers (Akintola and Adekeye 2008). Thousands of pegmatites occur in this belt, most of which have been mapped to some extent, scientific manner (Rahaman, 1981). Potassium feldspar, albitic plagioclase, quartz, and subordinate, if any muscovite and/or biotite constitute the major minerals while a wide spread spectrum of minerals including lepidolite, tourmaline (green, pink, black and blue),beryl, chrysoberyl, apatite, amblygonite, monazite, lithiophyllite-triphyllite, ghanite, cassiterite, wodginite, nigerite, columbo-tantalite, tapiolite, microlite, bismuthinite, bismuthite, scheelite, cholite, andalusite and sillimanite occur as accessory minerals in the pegmatites (Okunlola, 2005,2007; Bowden, 1984; Tischerdorf, 1977).

The ages, mineralogy, and composition of these pegmatite units appear to be analogous to those of the pegmatite's environment in Brazil, Canada, and Australia (Preinfalk, 2000). The pegmatitic belt and the orientation of the units within it appear to be related to rotational stresses created by the Benue Trough (Rahaman, 1981; 1988). From a more global perspective, this trend is probably the northern extension of the Brazilian pegmatite belt, which runs from Rio Grande del Sul to Rio Grande del Norte. The pegmatite field of this study area is part of late Pan African, (Jacobson and Webb, 1949; Wright, 1970), rare (specialty) metals granitic pegmatites. The primary mineralization of tantalum, niobium, tin, beryllium, and lithium is hosted in quartz-feldspar-muscovite pegmatites (Kinnaird *et al.,* 1984; Raimbault *et al.,* 1995; Okunlola *et al.,* 2005).

Most pegmatites are composed of quartz, feldspar and mica, having a similar silicic composition as granite. Rarer intermediate composition and mafic pegmatites containing amphibole, Ca-plagioclase feldspar, pyroxene, feldspathoids and other unusual minerals are known, found in recrystallized zones and apophyses associated with large layered intrusions. Crystal size is the most striking feature of pegmatites, with crystals usually over 5 cm in size (Fig.1). Individual crystals over 10 meters (33 ft) long have been found, and many of the world's largest crystals were found within pegmatites (Rahaman, 1988). These include spodumene, microcline, beryl, and tourmaline.

Geochemically, pegmatites typically have major element compositions approximating "granite", however, when found in association with granitic plutons it is likely that a pegmatite dike will have a different trace element composition with greater enrichment in large-ion lithophile (incompatible) elements, boron, beryllium, aluminium, potassium and lithium, uranium, thorium, cesium, (Kinnaird, 1984). Occasionally, enrichment in the unusual trace elements will result in crystallization of equally unusual and rare minerals such as beryl, tourmaline, columbite, tantalite, zinnwaldite and so forth. In most cases, there is no genetic significance to the presence of rare mineralogy within a pegmatite, however it is possible to see some causative and genetic links between, say, tourmaline-bearing granite dikes and tourmaline-bearing pegmatites within the area of influence of a composite granite intrusion (Kinnaird *et al.,* 1984; Matheis, 1983).

This paper examines the geology, the provenance of the pegmatite based on their geochemical characteristics and evaluate both the chemical weathering, and mineralization potential of pegmatite of the study area.

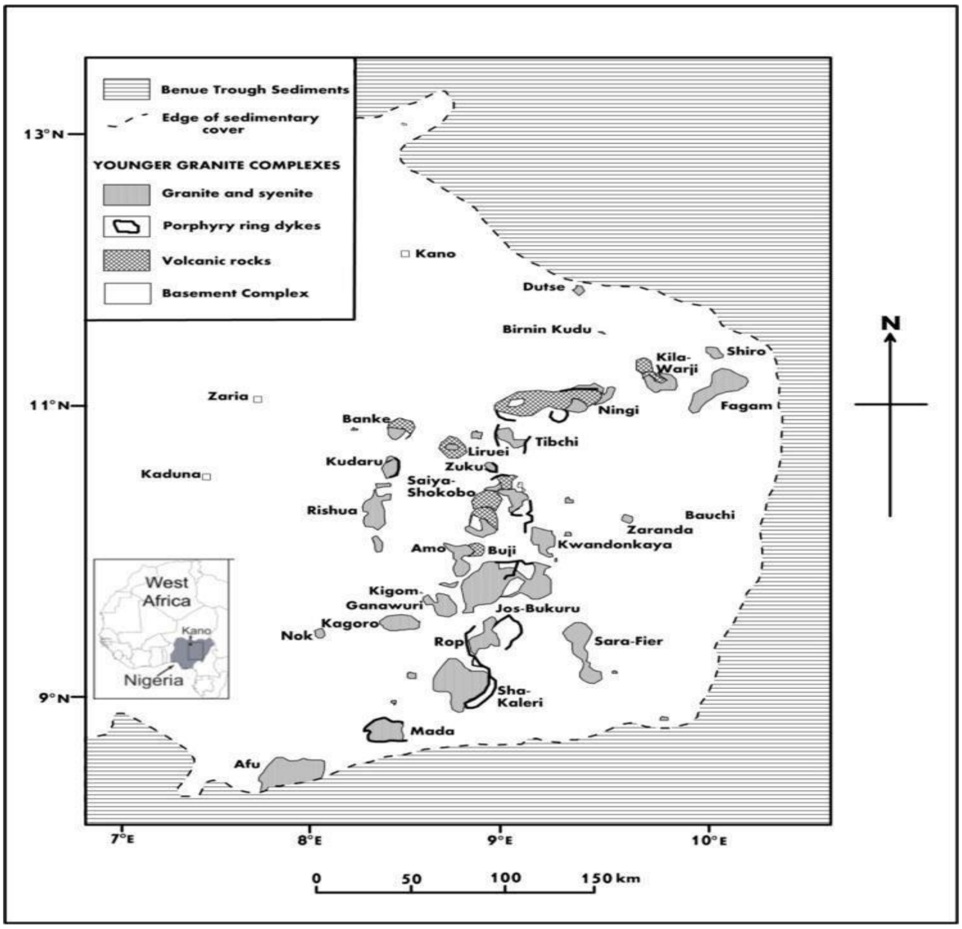

Fig.1. Geological Map of Nigeria Showing the Regional Fractures and Location of Areas of Rare-metal and Barren Pegmatites (Garba, 2003)

1.2. Geologic Settings

The Nigeria basement complex forms a part of the Pan-African mobile belt and lies between the West African and Congo Cratons (Fig.2). It is intruded by the Mesozoic calc-alkaline ring complexes (Younger Granites) of the Jos Plateau and is unconformably overlain by Cretaceous and younger sediments. The Nigerian basement was affected by the 600Ma Pan-African orogeny, and it occupies the reactivated region which resulted from plate collision between the passive continental margin of the West African craton and the active Pharusian continental margin (Burke and Dewey, 1972; Dada, 1997). 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). Basement complex rocks are subdivided into migmatite-gneiss complexes; the older metasediments; the younger metasediments; the older granites; and the younger granite alkaline ring complexes and volcanic rocks. The migmatite-gneiss complex is the commonest rock type in the Nigerian Basement complex. It comprises two main types of gneisses: the biotite-gneiss and the banded gneiss. Very widespread, the biotitic gneisses are normally fine-grained with strong foliation caused by the parallel arrangement of alternating dark and light minerals. The banded gneisses show alternating light-coloured and dark bands and exhibit intricate folding of their bands. The migmatite gneiss complex is the oldest basement rock and is believed to be of sedimentary origin but was later profoundly altered into metamorphic and granite conditions. The older meta-sediments were also among the earliest rocks to form on the Nigerian Basement Complex. Initially of sedimentary origin, with a more extensive distribution, the older meta-sediments underwent prolonged, repeated metamorphism; and now occur as quartzites (ancient sand-stones), marble (ancient limestone's), and other calcareous and relics of highly altered clayey sediments and igneous rocks. Most parts of the Basement complex are underlain by belts of roughly north-south trending, slightly metamorphosed ancient Pre-Cambrian sedimentary and volcanic rocks known as the younger meta-sediments. The major rock types are ancient shaly rocks which are now referred to as quartz- biotite-muscovite schist. These change laterally into coarse-grained feldspar-bearing micaceous schists. Schists with graphite, phyllites and chlorite are common. Ferruginous quartzites and tale schists also occur. The younger metasediments contain most of the gold deposits in Nigeria in the northwest around Maru and Anka, and at Zuru; near Kaduna, and at llesha in southwestern Nigeria. Older granites are widespread throughout the Basement Complex and occur as large circular masses within the schists and the older Migmatite – Gneiss complexes. The older granites vary extensively in composition. The younger granite complexes in Nigeria are found mainly on the Jos Plateau, forming a distinctive group of intrusive and volcanic rocks that are bounded by ring dykes or ring faults. Other occurrences approximate a north-south belt towards the middle Benue in the south where the ages are younger and towards Niger Republic in the north where the younger granites are older. There is enormous variety in the granite composition of these rocks.

The study area is situated about 50km NE of Ilorin and about 80km SE of Jebba, in part of the Precambrian Basement Complex of south-western Nigeria, east of the West African Craton (Fig. 3). Varieties of gneisses, some of which are migmatized, outcrop in various parts of Nigeria and have been described under different nomenclatures such as banded gneiss, early gneiss, and grey gneisses. They are also sometimes referred to as granodioritic, tonalitic or granitic gneisses based on origin and petrography (Adedoyin, 2015; Annor, 1986). Gneisses have been studied by several authors (Adedoyin, 2015; Okonkwo and Garnev, 2012a, 2012b; Kroner *et al.,* 2001; Dada, 1989; Dada *et al.,* 1995; Dada, 1999). King and de Swardt (1949) worked around the south-eastern quadrant of Sheet 224, which is outside the present mapped area while (Oluyide *et al.*, 1998) worked on the adjoining Ilorin Sheet to the west and both constrained the gneisses to the Precambrian. Based on field associations with meta-sediments, Oluyide (1998) is of the opinion that the migmatitic gneisses of Ilorin area (Sheet 50), to the west, are of sedimentary origin. But, Rahaman (1988) opined, as we do, that field methods are often inadequate determining the origin. In Jebba area, northwest of the present study area, although the migmatitic gneisses were constrained to a sedimentary parentage (Okonkwo and Wincester, 1996), yet, about one-third of their samples point to igneous sources. However (Odigi, 2002) got a contrary source for the Bode Saadu orthogneisses, southwest of Jebba, which they constrained to be calc alkaline, magnesian, metaluminous and of Eburnean age.

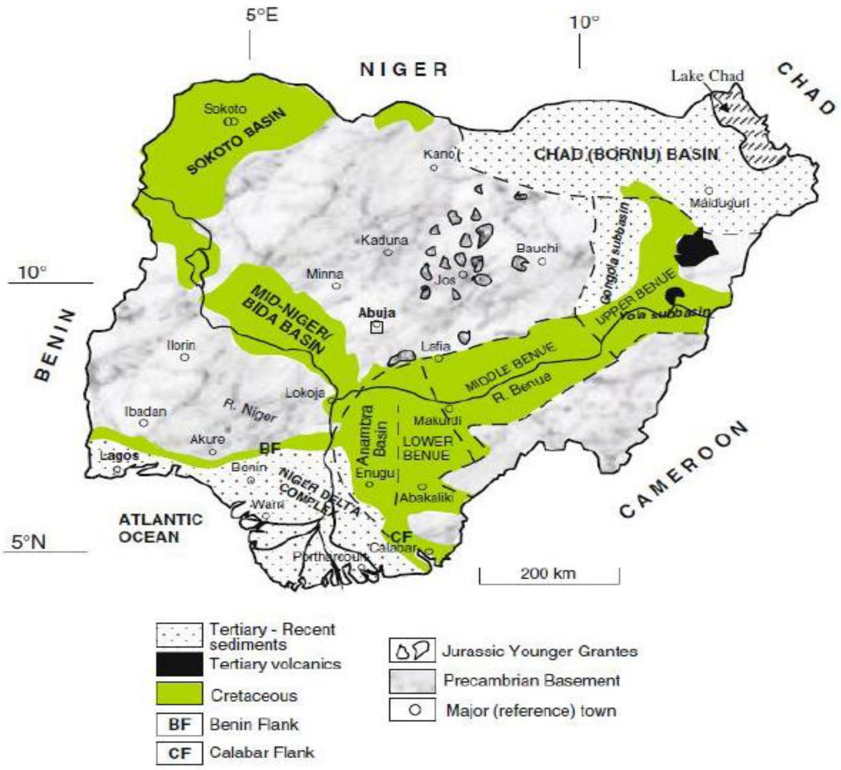

Fig. 2. Geological map of Nigeria showing major lithological units (Obaje, 2009).

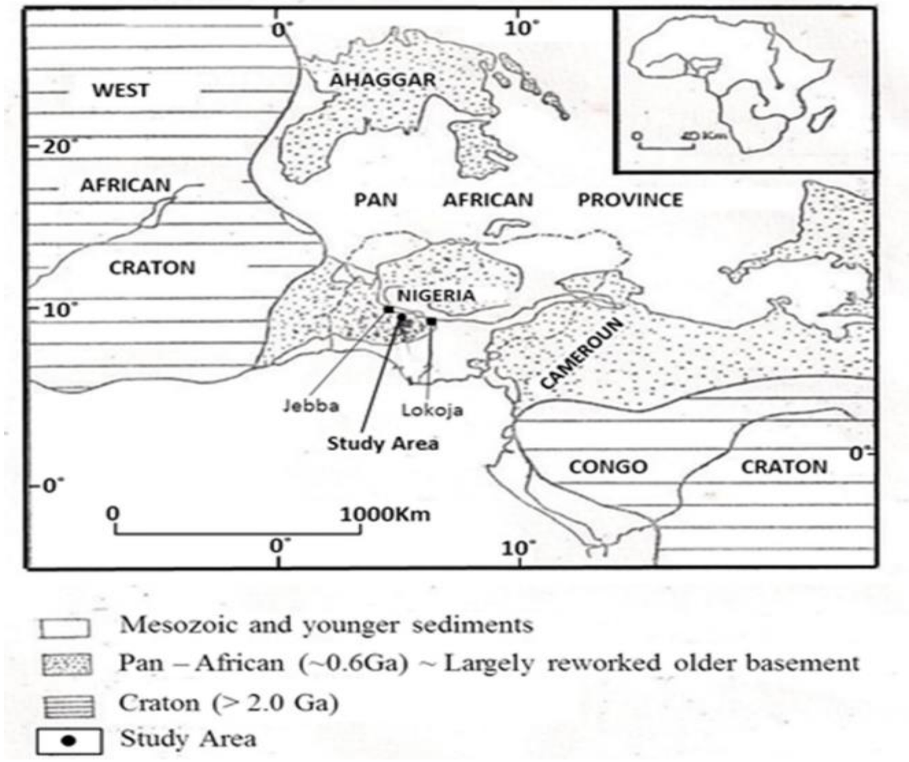

Fig. 2. Map Showing the location of the Study Area.

2. Methods

The laboratory work involved diving of the Nine (8) stream sediments samples (PG01, PG02, PG03, PG04, PG05, PG14, PG15, PG17) that have been dried and were taken for geochemical analysis to investigate the major oxides and trace elements for possible mineralization of the pegmatite of the study area.

A total of eight samples were collected from the study area for analysis which were put in a sample bag for onward transmission to the laboratory. Prior to whole rock geochemical analysis, about 50–100g of each selected samples were reduced to chips of 2–4 mm and pulverized in a thoroughly cleaned agate ring mill to avoid contamination. 0.2 g aliquot of samples for the major element analysis were weighed into a graphite crucible and mixed with 1.50 g of $LiBO_2/Li_2B_4O_7$ flux and these were subjected to a temperature of 980 °C for thirty minutes. The residue was later dissolved in 5% HNO_3 (ACS grade nitric acid diluted in distilled water). Replicate analyses show that errors for major elements vary between 1 and 2%. Trace and rare elements analysis, 50.0mg of each sample was digested with mixture of 3.0 ml of concentrated HF, 1.0 ml of concentratedHNO_3 and 1.0 ml of concentrated $HClO_4$ for forty eight hours in a tightly closed Teflon vessel on a hot plate at temperature <150 °C. The solution was then dried s and extracted using 60.0 ml of 1% HNO_3. The samples were analyzed for major and trace elements using the Inductive Couples Plasma Optical Emission Spectrometer (ICPMS) technique, using inductively coupled atomic emission spectrophotometry (ICP-MS) and X-ray florescence (XRF) techniques.

3. Results and Discussion.

3.1 Geochemical Analysis

The concentration of the major elements (SiO_2, Al_2O_3, Fe_2O_3, CaO, K_2O, TiO_2, P_2O_5, MnO, MgO, Na_2O, and LOI, in weight%); trace elements (Co,Cu,No,Pb,Rb,S,Sb,Sn,Ni,As,Mo,Zn, and Cd in ppm) are presented in Table 1 and Table 2.

The analytical results of the major oxide composition as presented in (Table 1), shows that the samples of the Oke Ode pegmatite are highly siliceous with SiO_2 content ranging from 56.6-62.0% with an average of 59.32%, the Al_2O_3 ranges from 6.80-8.39% with an average of 7.59 %, also the Fe_2O_3 ranges from 2.89-3.86% with a mean value of 3.38%. The range and mean contents of other major oxides in the pegmatites of Oke Ode are as follows; MnO (0.04 -0.27%, 0.16%), MgO (0.00-0.00%, 0.00%), CaO (1.65-1.86%, 3.51%), Na_2O (0.00-0.00%, 0.00%), K_2O (4.75-7.33%,6.04%), TiO_2 (<0.001-0.02%, 0.01%), P_2O_5 (0.66-2.30%, 2.96%) and Cr_2O_3 (<0.03-0.03%, 0.03%).

Table 1

Major Oxides with Some Ratios

Major Oxide (wt%)	PG01	PG02	PG03	PG04	PG05	PG14	PG15	PG17	Avg
SiO_2	61.5	56.5	57.8	60.2	62	61.3	60.7	57.7	59.71
Al_2O_3	7.38	6.8	6.95	7.24	7.46	8.39	8.27	6.93	7.43
Fe_2O_3	3.83	3.53	3.6	3.76	3.86	2.9	2.89	3.6	3.50
CaO	1.79	1.65	1.67	1.75	1.8	1.86	1.85	1.68	1.76
K_2O	7.28	6.69	6.84	7.13	7.33	5.01	4.75	6.83	6.48
TiO_2	0.02	0.02	0.02	0.02	0.02	-	-	0.01	0.01
MnO_2	0.04	0.04	0.04	0.04	0.04	0.27	0.27	0.04	0.10
MgO	-	-	-	-	-	-	-	-	0.00
Na_2O	-	-	-	-	-	-	-	-	0.00
P_2O_5	1.17	1.07	1.09	1.15	1.16	0.66	0.64	1.09	1.00
Cr_2O_3	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
K_2O/Al_2O_3	0.99	0.98	0.99	0.97	0.98	0	0.57	0.99	0.81
Na_2O+K_2O	7.28	6.69	6.84	7.13	7.33	5.01	4.75	6.83	6.48
$Al_2O_3/CaO+Na_2O+K_2O$	0.82	0.81	0.8	0.82	0.79	1.22	1.25	0.8	0.91
Al_2O_3/Na_2O+K_2O	1.01	1.02	1.02	1	0.91	1.67	1.74	1.02	1.17
Na_2O/ K_2O	0	0	0	0	0	0	0	0	0.00
Na_2O+K_2O- CaO	5.49	5.04	5.17	5.38	5.53	3.15	2.9	5.15	4.73
Fe_2O_3 + MgO	3.83	3.53	3.6	3.76	3.86	2.9	2.89	3.6	3.50
CIA	44.86	41.34	42.25	44.01	45.35	51.00	50.27	42.13	45.15
PIA	12.20	12.35	12.50	12.20	12.66	8.20	8.00	12.50	11.32
CIW	80.48	74.15	75.79	78.95	81.35	91.49	90.19	75.57	81.00

[a] CIA = molar $[Al_2O_3/(Al_2O_3+CaO{*}+Na_2O + K_2O)]\times 100$.

[b] PIA = $[(Al_2O_3–K_2O)/(Al_2O_3+CaO{*}+Na_2O + K_2O)]\times 100$.

[c] CIW = $[Al_2O_3/(Al_2O_3+CaO{*}+Na_2O)] \times 100$.

(Nesbitt and Young, 1982), CIA = Chemical Index of Alteration, PIA = Plagioclase Index of Alteration, CIW = Chemical Index of Weathering, ICV = Index of Chemical Variability.

The major element geochemical composition of pegmatites is dependent on chemical weathering (Nesbitt *et al.*, 1996) and can be determined based on chemical index of alteration (CIA) and chemical index of weathering (CIW). This is obtained in molecular proportions according to Nesbitt and Young (1982, 1984, 1996). The chemical index of alteration (CIA) value indicates a higher degree of chemical alteration for the pegmatites whereas chemical index of weathering (CIW) value can be due to either absence of intense recycling in a humid climate or intense recycling in an arid/semiarid climate (Osae *et al.*, 2006). Descourvieres *et al.*, (2011) and Fedo *et al.*, (1995) also stated that CIA is a dimensionless parameter corresponding to increasing weathering and sediment maturity. Values ranging between 50.0 and 60.0 indicate a low degree of chemical weathering, between 60.0 and 80.0 moderate weathering while values greater than 80.0 indicate extreme chemical weathering. Generally, the increasing values of CIA/CIW from low to high is directly related to the intensity chemical weathering. Therefore, the high values of CIA (41.25–51.00; average-45.15) and CIW (74.15–91.49; average-81) from the study area (Table 1), reflect a low to an intensive chemical weathering under humid climate. Also, plagioclase index of alteration (PIA) is strongly applicable to determination of the degree of chemical weathering undergone by the rocks in the source area (McLennan *et al.*, 1993; Fedo *et al.*, 1995). Low PIA value for the studied pegmatites (8.00–12.66; average-11.32) indicates a low weathering (recycling).

The geochemical data displaying the ratios of Al_2O_3/Na_2O +K_2O +CaO for the various samples are shown in Table 1. The alumina (Al_2O_3) is greater than the alkali Na_2O + K O +CaO in all the rock samples by values ranging between 0.79 and 1.25 wt % implying that the samples analyzed are peraluminous (Miller, 1985). MgO (0.00-0.00wt%), CaO (1.65-1.86%), and Fe_2O_3 (2.89-3.86 wt %) have low contents which indicates the samples are fertile and peraluminous (Cerny *et al.*,1981, 1984,1991a; Longstaff, 1982; London, 2014). A plot of Al_2O_3/ (CaO + Na_2O + K_2O) versus Al_2O_3/Na_2O + K_2O in Fig. 4 shows and confirms the peraluminous character of the pegmatite from Oke Ode. Wilson, (1991) stated that peraluminous granites contain crustal or sedimentary materials in their original magma. Also, a plot of rock in the S-type field implies that the original magma from which the pegmatite was formed contained great amount of sedimentary or crustal materials.

The low ratio value of Na_2O/K_2O indicates that the pegmatites are highly chemically mature. Pettijohn (1987) attribute low Na_2O/K_2O ratio to the dominance of K-feldspar and K-mica over albite plagioclase. The abundance of feldspar and mica are geochemical indicators of Sn-Ta mineralization (Cerny *et al.*, 1981). High potash content in any rock is an indication that generation of the magma is plutonic (Martin, 2005). An AFM diagram in terms of the alkalies (Na_2O +K_2O), Fe_2O_3, and MgO shows that the samples plotted in both the tholeiitic and calc-alkaline fields (Fig. 5). The line separates the tholeiitic fields from the calc-alkaline fields. The tholeiitic rocks normally show stronger Fe -enrichment relative to Mg than do the Calc-alkaline while the calc-alkaline shows enrichment in silica and alkalies (Miyashiro, 1974). The plotting of the samples in both the tholeiitic and calc-alkaline fields shows that the magma from which the pegmatite was formed was not totally restricted in occurrence only to subduction-related environment. This suggests that the pegmatite may have been derived not only from subduction tectonic environment but also from the oceanic crust of calc-alkaline environments.

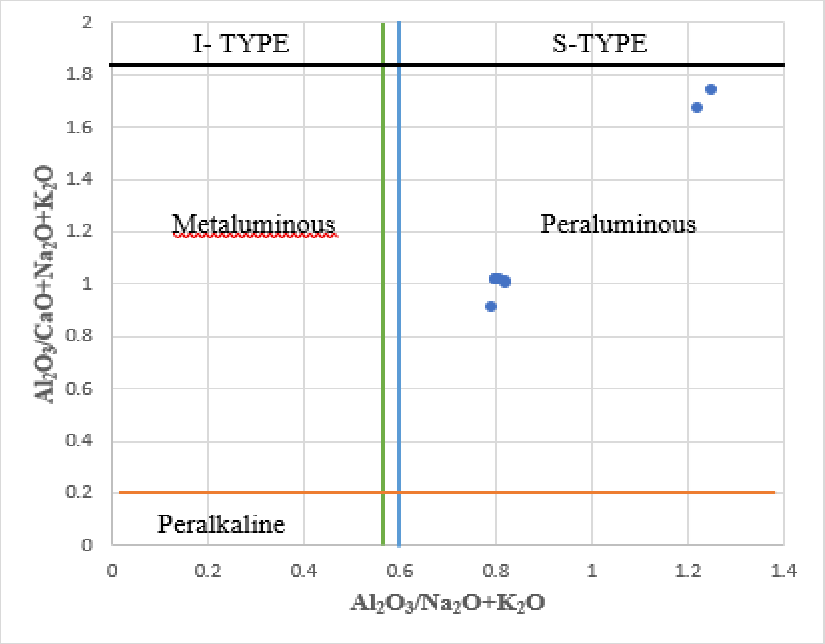

Fig. 4. $Al_2O_3/CaO + Na_2O + K_2O$ versus $Al_2O_3/Na_2O + K_2O$ plot showing the dominantly Paraluminus nature of the rocks (after Maniar and Piccoli, 1989)

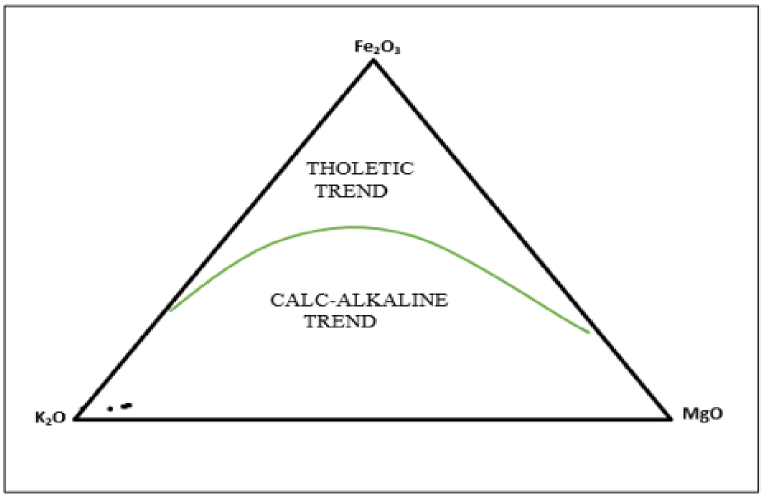

Fig. 5. AFM diagram for rocks in the study area discriminating calc-alkaline field tholeiitic (Irvine and Baragar, 1971).

Fig. 6 shows that the pegmatite samples plotted on both the igneous, sedimentary, and metasedimentary origins as seen in a plot of Na_2O/Al_2O_3 versus K_2O/Al_2O_3 (Garrels and Mackenzie, 1971), supporting the derivation of materials that made up the rock from single sources. Meanwhile, the plot of TiO_2-K_2O-P_2O_5 in Fig. 7 indicates that substantial samples plotted in the continental crust. High potash content (alkalies) with relative Fe-enrichment and silica suggests the plutonic generation of magma. and the development of the pegmatite in both the oceanic and continental crusts.

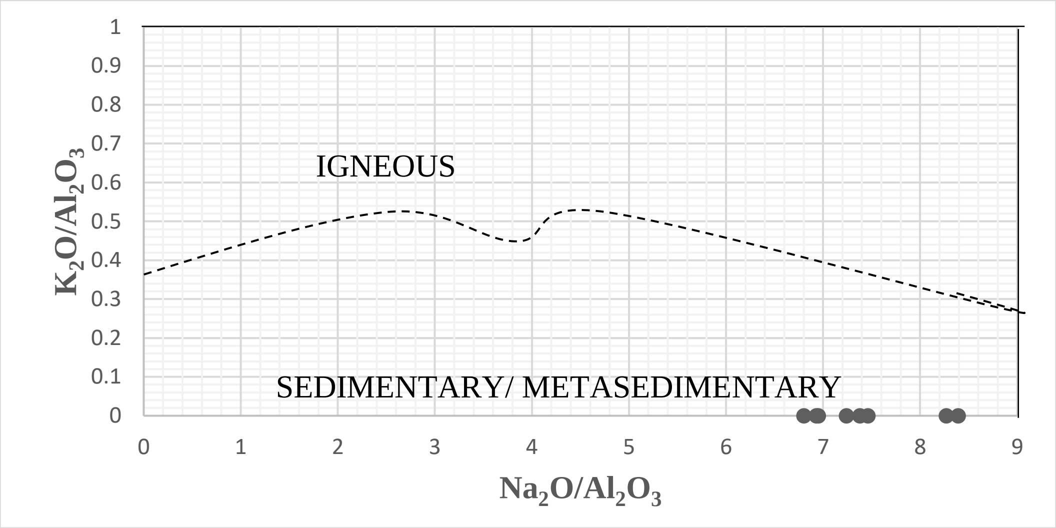

Fig. 6. Na_2O/Al_2O_3 vs. K_2O/Al_2O_3 plot for pegmatites at Oke Ode (Garrels and Mackenzie, 1971)

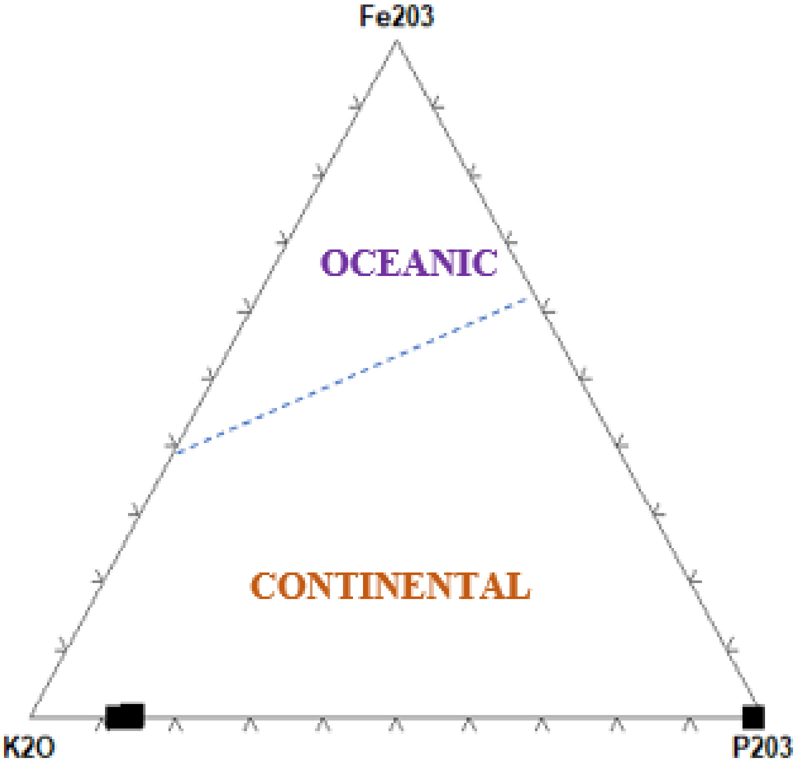

Fig.7. TiO_2-K_2O-P_2O_5 plot of the Rocks (Pearce *et al.*, 1975)

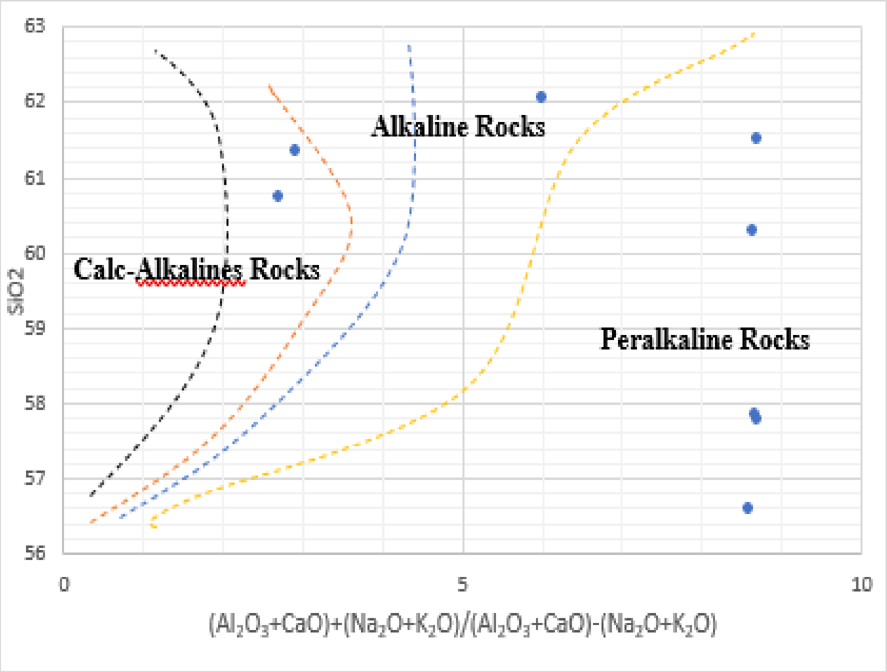

Fig.8. (Al_2O_3+CaO) $+(Na_2O+K_2O)$ / $(Al_2O_3+CaO)-(Na_2O+K_2O)$ versus SiO_2 (Wright, 1969).

A plot of (Al_2O_3+CaO) $+(Na_2O+K_2O)/(Al_2O_3+CaO)$ $-(Na_2O+K_2O)$ versus SiO_2 (after Wright, 1969) reveals that all the pegmatite samples plotted on the peralkaline rocks. Using the aluminum saturation index (ASI) proposed by Zen, (1988), that rocks which have ASI > 1·0 are corundum-normative and are termed peraluminous, meaning that they have more Al than can be accommodated in feldspars and that they must have another aluminous phase present. Furthermore, if ASI < 1·0 and Na + K > Al, the rock is peralkaline. Going by the plots in Fig.7 and 8, the pegmatite samples are aluminous as well as peralkaline. The diagnostic minerals in strongly peralkaline rocks are the sodic amphiboles and pyroxenes. In strongly peraluminous granites the phase can be muscovite, cordierite, garnet or an Al_2SiO_5 polymorph, but they are commonly taken to have formed from a sedimentary source (Chappell and White, 1974), again strongly peraluminous melts may form by melting of biotite-bearing metaluminous felsic rocks (Miller, 1985) or even by water-excess melting of mafic rocks (Ellis and Thompson, 1986). All these come to indicate that the pegmatite from Oke Ode may have formed from mixed plutonic sources.

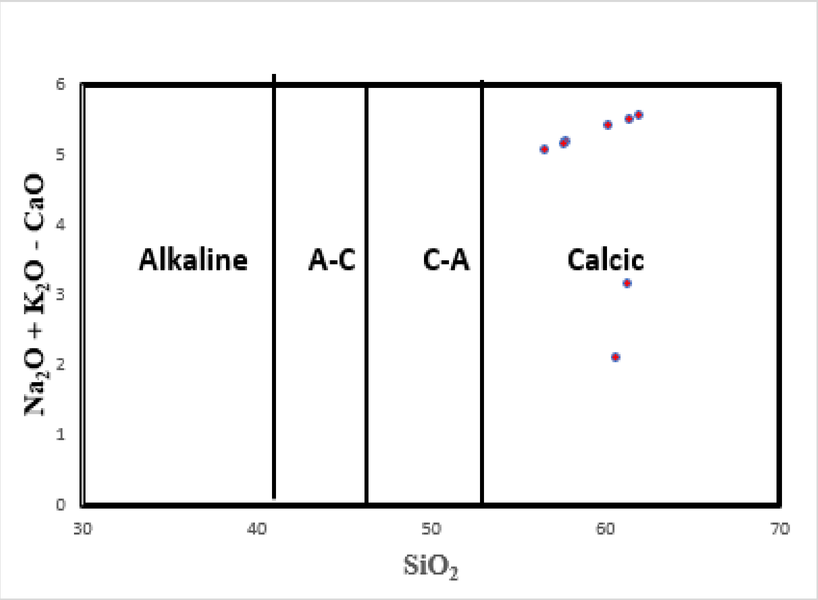

Fig.9. Na_2O + K_2O-CaO versus SiO_2 diagram after Peacock (1931) showing the classification of the major rocks into Alkaline, A-C (alkali-calcic), C-A (calcic-alkali) and Calcic groups.

The samples in Fig. 9 and Fig. 10 plotted in the calcic class after Peacock (1931) just like in Na_2O+K_2O-CaO versus SiO_2 diagram, where the pegmatites plotted in the calcic to calcic-alkali fields and all the pegmatite samples plotted in the alkalic field pointing to the fact of mixed sources of materials in the magma that formed the rock.

From Fig. 11 it is indicated that the pegmatite samples of the study area are rich with ferroan minerals.

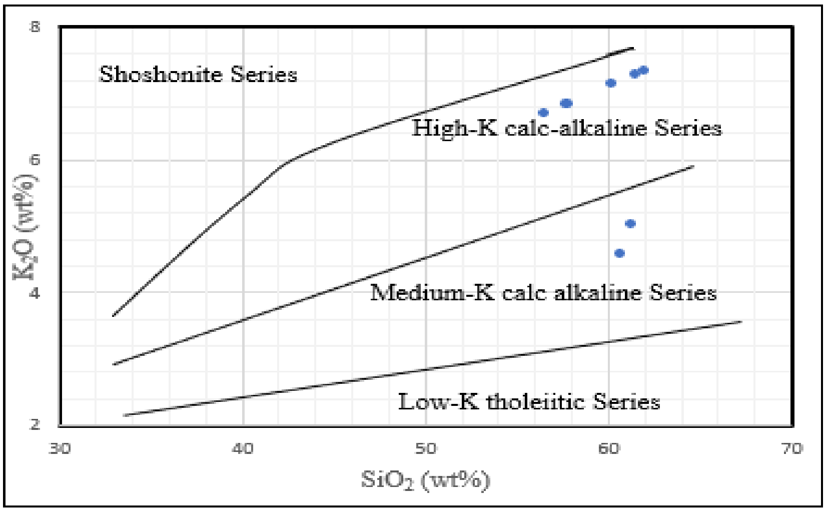

Fig. 10. K_2O versus SiO_2 diagram after Peacock (1931)

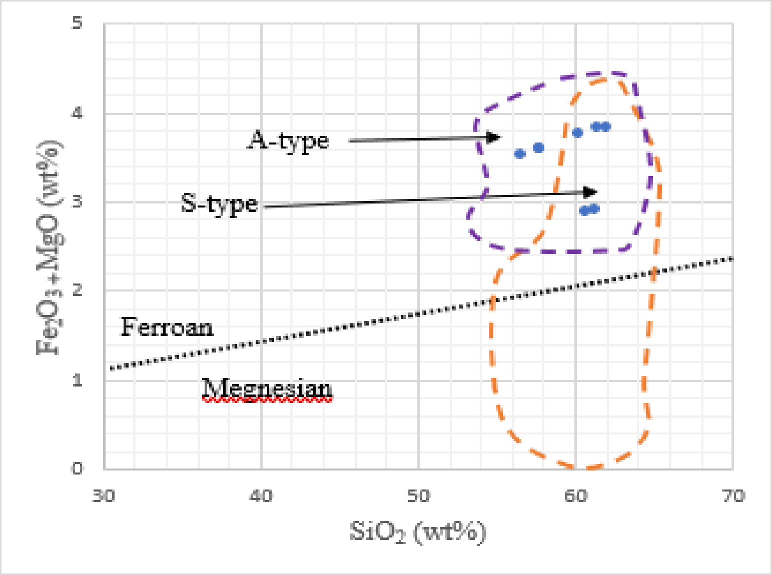

Fig.11. $Fe_2O_3 + MgO$ versus SiO_2 diagram after Peacock (1931)

Table 2 shows the characteristics of the few trace elements analyzed from the pegmatite and it could be seen as the values of As, Mo, Rb and Zn with an average of 6.00ppm, 31.50ppm, 163.38ppm, and 28.00ppm, respectively are higher than the background of trace elements in common rocks. This indicates that the As, Mo, Rb, and Zn are abundant in all the pegmatite of the study area. Rb ranges between 103 and 190ppm. Co and Pb are strongly depleted. Sb values are between 76 and 84 ppm as Sn ranges from 55 to 61 ppm. The compatible elements Ni (9-10) and Cu (17-20) have low concentrations. The low concentrations of these two compatible elements suggest that the materials that formed the pegmatite are derived from a depleted or metasomatized mantle.

Table 2

X-ray fluorescence (XRF) Analysis of Pegmatite in Oke Ode Area (Values in ppm)

Trace Elements(ppm)	PG01	PG02	PG03	PG04	PG05	PG14	PG15	PG17
Co	7.00	6.00	7.00	7.00	6.00	6.00	7.00	7.00
Cu	20.0	18.0	19.0	20.0	20.0	17.0	17.0	19.0
Nb	20.0	18.0	19.0	20.0	20.0	40.0	40.0	19.0
Pb	5.00	5.00	5.00	5.00	5.00	9.00	8.00	5.00
S	39.0	36.0	37.0	38.0	39.0	43.0	42.0	37.0
Sb	83.0	76.0	78.0	81.0	84.0	78.0	77.0	78.0
Sn	60.0	55.0	56.0	59.0	61.0	61.0	60.0	56.0
Ni	10.0	9.00	9.00	10.0	10.0	10.0	9.00	9.00
As	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Mo	32.0	29.0	30.0	31.0	32.0	34.0	34.0	30.0
Zn	29.0	27.0	27.0	28.0	29.0	29.0	28.0	27.0
Rb	190	175	179	186	192	104	103	178

[a]ppm: per part million.

4. Conclusion

Geochemical analysis reveals that the pegmatites from Oke-Ode, have high SiO_2 content 56.6-62.0wt%, low Na_2O/K_2O ratio and are strongly peraluminous and peralkaline. The diagnostic minerals in strongly peralkaline rocks are the sodic amphiboles and pyroxenes. In strongly peraluminous granites the phase can be muscovite, cordierite, garnet or an Al_2SiO_5 polymorph, but they are commonly taken to have formed from a sedimentary source strongly peraluminous melts may form by melting of biotite-bearing metaluminous felsic rocks or even by water excess melting of mafic rocks. All these come to indicate that the pegmatite from Oke Ode may have been formed from mixed plutonic sources. Low ratio of Na_2O/K_2O with high Al_2O_3 content are consistent with kaolin/feldspar formation in the Oke-Ode area. The abundance of trace elements such as As, Mo, Rb and Zn indicates there is possibility of mineralization of sphalerite, gold, and copper ores.

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