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COMPOSITIONAL FEATURES OF PRECAMBRIAN PEGMATITES OF ITAKPE AREA, CENTRAL NIGERIA

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ABSTRACT

Precambrian pegmatites occurring as near vertical dykes have been studied in Itakpe area, with a view to elucidate their compositional features and possible economic values.

They are found intruding the older assemblages of amphibolites/amphibolitic schists, granitic gneisses and the banded iron formation Usually coarse grained in texture, thin section study show they contain mainly quartz, and microcline, as the main minerals with subordinate plagioclase, and muscovite, while opaques mainly magnetite and hematite are of accessory constituents.

Geochemical analysis of eleven samples for major and trace elements using Inductively Coupled Plasma-Atomic-Emission Spectrometry (ICP-AES) analytical method shows they are generally highly siliceous with silica values ranging from 64.97-74.24% while Al_2O_3, content could be as high as 23.78%. However, FeO, Fe_2O_3, TiO_2 P_2O_5, are generally low (less than 1.00%) The samples are fairly enriched in Rb, Ba, Sr, Zr, but comparatively, poor in the rare metals Ta, Nb, W, and Sn. Cs values are also less than 2ppm Be is however marginally high (103-152ppm). Na/k ratio are all less than (1.0) indicating poor albitisation. Plots of K/Rb against Rb show poor fractionation trend with all the samples plotting in the barren rare metal field. Zr against Sr plot of samples does not show evidence of post magmatic alterations. Ba/Rb ratio (5.7) is high while Rb/CS, Rb/Sr, ratio, (0.21-0.32) is relatively low and non variable.

Rare metal mineralization enrichment indices viz Ta/Cs Ta/W/CS, Be/K/Rb Ta/Ga plots show its depletion in rare metal mineralization Chondrite normalized REE shows enrichment of the LREE (Y, Ce, Pr, Nd) relative to the HREE (Dy,Ho, Er, Tm and Yb).

KEYWORDS: Precambrian, Pegmatites, Siliceous, Mineralization, rare metal

INTRODUCTION

Pegmatites are known worldwide to serve as host to economically important mineral deposits such as gem stones and rare metals such as tantalum niobium, tin and tungsten. Precambrian pegmatites of Nigeria occur mostly as dyke like intrusions which vary from few metres to several kilometers in length and few centimetres to metres in width and have been hitherto thought to be confined to a broad 400km long NW-SE trending belt stretching from Wamba area in central Nigeria to Ibadan area, south western Nigeria However, recent studies (Garba 2001, Okunlola 2004), have shown that they are not restricted only to these confines. The southeast Obudu hills occurrences are even thought to extend into north east Brazil (Garba, 2003; Ekwueme, 2004). The pegmatites evolved during the time span of 600-530 Ma, (Matheis and Can Vichelte 1983), which indicates formation during the latter periods of Pan African Magmatism.

In recent times, there has been a resurgence of interest in the study of these pegmatites occurrences because of its associated economic rare metal and gem mineralization. This has led to concentration of study on discrimination of the pegmatites into the rare mental mineralized and barren ones in order to elucidate modes and features of mineralization (Matheis, 1981; Matheis et al 1982; Kuster, 1990; Garba, 2003). Recently, Okunlola, (2004) defined the metallogeny of the rare metal Ta – Nb pegmatites of Nigeria outlining 7 broad fields namely Kabba-Isanlu, Ijero-Aramoko, Keffi-Nasarrawa, Ndeji, Oke Ogun, Ibadan-Osogbo, Kushaka-Birnin Gwari. The Itakpe pegmatites occurrences, which are members of the Kabba-Isanlu fields, have therefore been studied with the aim of elucidating the petrographic, and geochemical features with a view to understanding their genesis and economic potentials.

Regional Geological Setting

Rocks of the Precambrian basement complex of Nigeria underlie the project area. The Precambrian basement of African can be divided into three large masses or cratons These are the Kalahari craton, Congo and West African Cratons They are separated from each other by a number of mobile belts active in late Proterozoic times The Nigerian basement complex lies east of the Congo Craton in a mobile belt affected by the Pan African Orogeny These rocks outcrop in two large areas (viz the south-western and north-central parts of the country) and in smaller areas in the northeastern parts and the southeastern parts notably around the Oban massif and Obudu areas (Ekwueme 2000)

Three main lithologic groups are usually distinguished They are (i) a gneiss migmatite complex with evidences of polycyclic metamorphism mainly of amphibolites facies grade with ages Archaen and Pan African ages (ii) A N S tending schist belts of low grade supracrustal rocks with minor volcanic assemblages They are concentrated in the western half of Nigeria, although minor occurrences have been noted in the northern eastern and southern eastern parts (iii) Syn-late tectonic Pan African granite, which are collectively termed and Older Granites intrude the schist belts and the gneiss migmatite complex They comprise mainly granites pegmatites, gabbros, charnockites, diorites and syenites

The schist belts, despite paucity of agreements in terms of their nomenclature, geographic delimitation and geodynamic setting are composed largely of metamorphosed pelitic and psammitic assemblages Secondary lithologies such as ferrugineous rocks (Banded Iron Formation), carbonate, and metal ultramafic bodies are often used to discriminate them.

Lithological Association and Petrography

The pegmatites, which occur as near vertical dyke with average dip of 60^0 and strike mainly in the NNE-SSW direction, intrude into the older lithologies of granitic gneiss, schists and biotite granite (Fig.2) The banded gneiss which are members of an extensive migmatite gneiss complex rocks are mostly medium to coarse grained in texture. Characterized by ridge like exposures, they sometimes also form isolated inselbergs Foliation is marked by bands of felsic (quartz plagioclase, microcline) and mafic minerals (biotite, hornblende) Accessories to these include sphene, zircon, apatites and opaques

Two varieties of schists serve as major hosts of the pegmatite intrusions, they are biotite muscovite schists and amphibole schists They occur as deeply foliated bands of up to sometimes 10 metres in length The mica schists are mostly light grey in colour and composed of muscovite and biotite

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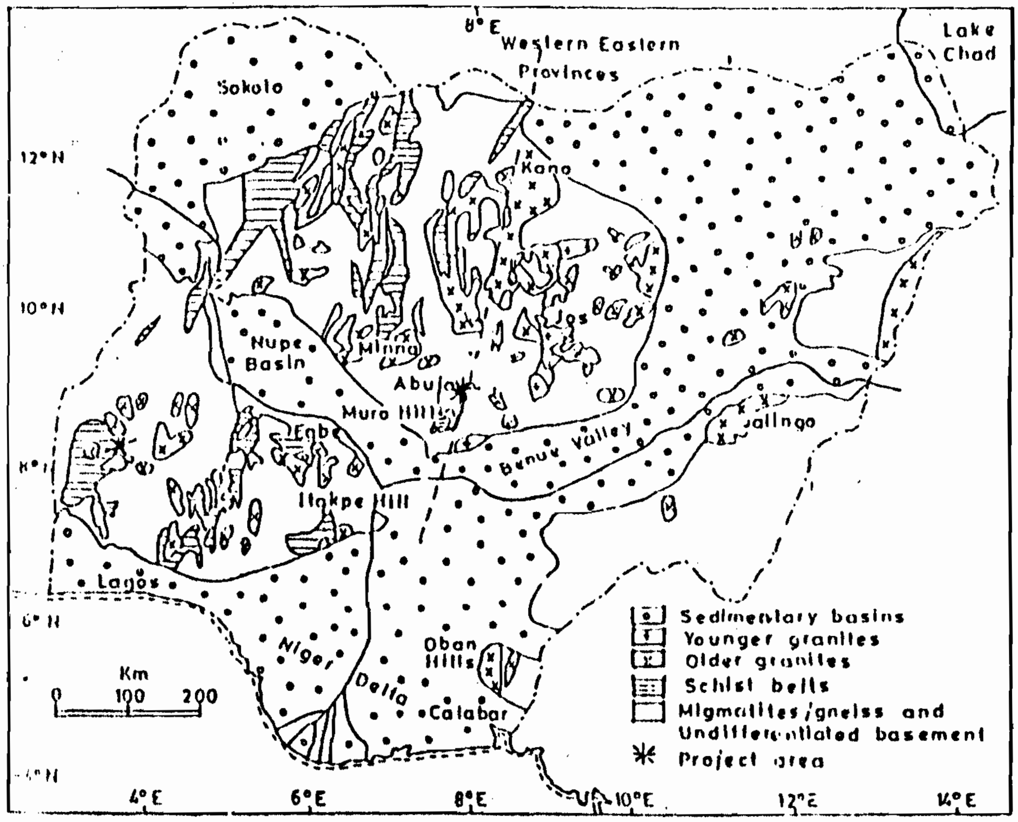

Fig. 1 Outline geological map of Nigeria showing location of project area.

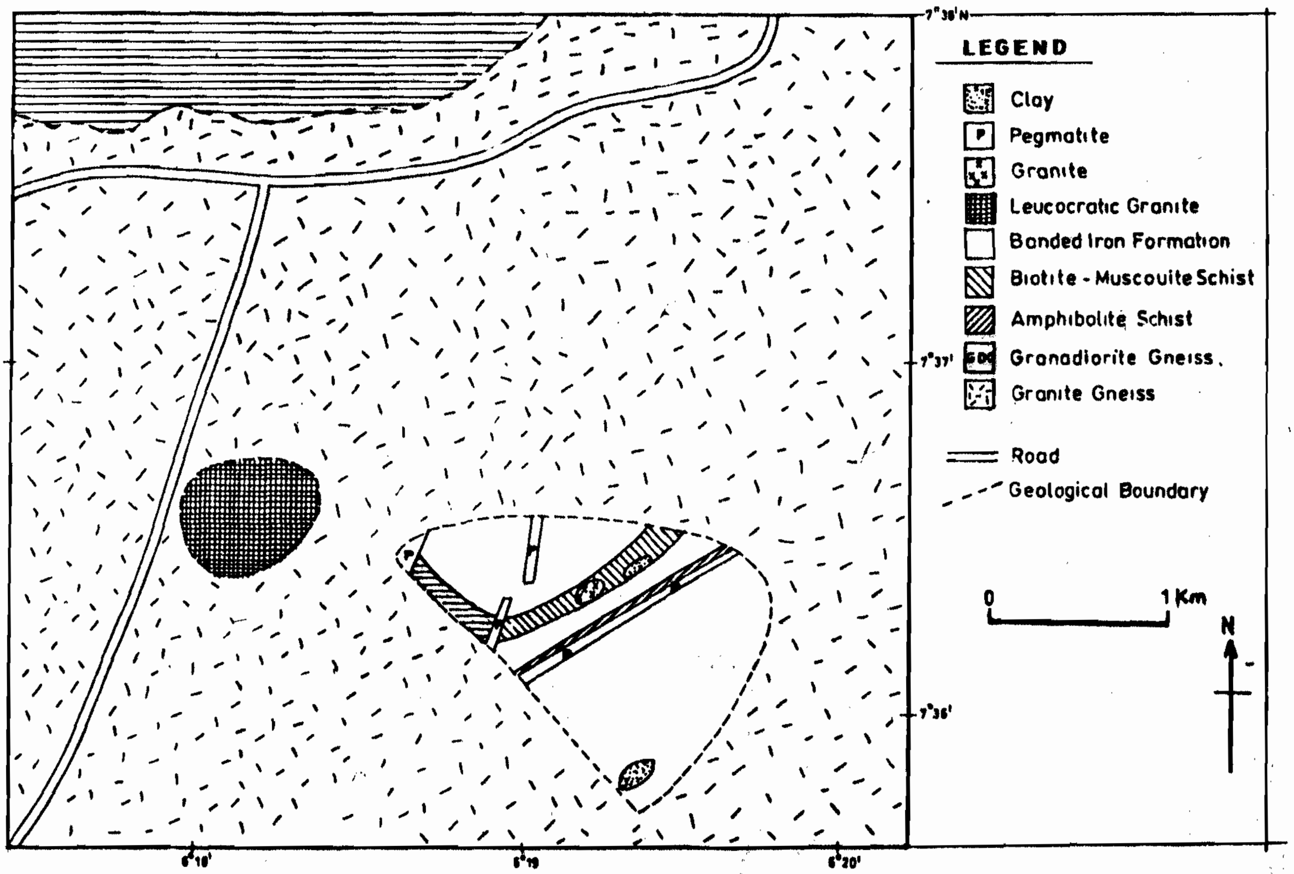

Fig.2.GEOLOGICAL MAP OF STUDY AREA IN ITAKPE MINING AREA

Fig 2a Photomicrograph of Pegmatite of Itakpe in transmitted light showing coarse Microcline (M), fine plates of Muscovite Mu and Quartz Q

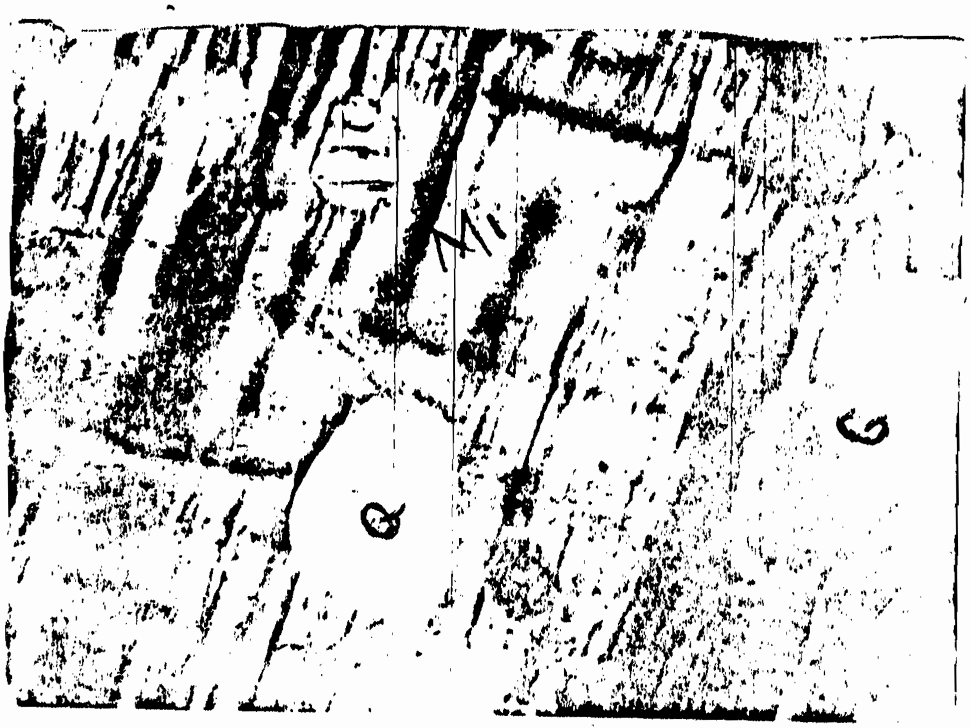

Fig 2b Photomicrograph of pegmatite of Itakpe in transmitted light showing poikilitic quartz Q in coarse polysynthetically twinned microcline Mi.

mainly with intergranular fine grained quartz. The amphibolitic schists occur as fine grained lenses and bands usually greenish, friable, and in most cases weathered. The older granite rocks occur as plugs at the middle of the Itakpe ridge. They are medium grained to porphyritic in texture. In places, feldspar megacrysts may be so abundant that the matrix is subordinate. Also granitic body displays foliated appearance, because of the orientation of the long axes of the megacrysts.

The banded iron formation (BIF), which is being mined in the area, occurs as numerous discontinuous bands on the surface. The bands are sometimes up to 30m thick with variable length of 15-20m. An estimated reserve of 200m tons has been calculated (Nigerian Iron Ore Mining Company, 2002) Two varieties, magnetite and heamatite have been mapped. The BIF consists essentially of iron rich and quartz rich bands intercalated discreetly on millimetric scales.

Residual clays, which occur as a result of weathering of feldspars within the pegmatites, occur in discreet lenses and they are often whitish in colour, with evidence of ferric percolations at the ridge top. They are textually plastic with localized irregular grittiness due to uneven quartz distribution within them.

Pegmatite occurs as coarse-grained complex veins, milky white in appearance with interstitial mica plates. They mostly intrude the schistose rocks and the Banded iron formation. Thin section study shows that the predominant mineralogical constituents include quartz, microcline, plagioclase, muscovite and minor amounts of biotite. Microcline is the most abundant of these minerals and they form coarse crystalline aggregates often graphically intergrown with quartz. They display characteristic crosshatched twinning and have an average modal composition of between 29% - 55%. Quartz is well distributed in all the samples and it is next in abundance to Microcline. It occurs as highly cracked or anhedral grains varying from colourless to milky white in plane polarized light and from colourless to blue under cross nicols. The average modal composition of quartz is about 32%. Plagioclase feldspars are colourless in thin section with characteristic albite twinning and average modal composition of about 42%. Muscovite occurs intergrown with microcline with colours ranging from white to greenish brown. The average modal composition of muscovite is about 9%. Biotite occurs in between the microcline Quartz and muscovite as dark brown platy grains with average modal composition of 4%. The modal proportions of the dominant mineralogical composition of some of the studied samples are presented in Table 1

Table 1: Average Modal Composition (%) of Minerals of Representative Samples

	L1	L2	L3	L4	L5	L6	L7	L8
Quartz	32	27	21	26	33	28	24	36
Microcline	40	36	55	40	43	47	46	35
Plagioclase	14	17	12	15	11	11	21	13
Muscovite	10	15	8	6	7	6	8	10
Biotite	2	3	4	3	4	8	1	2
Heavy Minerals	2	1	-	-	2	-	-	2

Geochemical Features

15 representatives muscovite extracts from samples were analysed for major, trace and rare earth elements using lithium metaborate/tetraborate fusion, inductively coupled Atomic Emission Spectrophotometry (ICP-AES) and an Inductively Coupled Plasma-mass spectrometry ICP – MS technique developed by Activation laboratories Ltd (ACTLABS), Ontario Canada.

RESULTS AND INTERPRETATION

The analytical results are presented in Table 2.

Major element distribution show that the pegmatites are siliceous with S_iO_2 content ranging between 64.47% and 72.24% with an average value of 70.59%. This is marginally lower than average values for rare metal Ta-Nb pegmatite of Nigeria (Okunlola, 2004) but comparable to the Ipetu-Ijesha barren pegmatites (Elueze, 1982). Fe_2O_3 (0.79% - 2.29%), Ca (0.05 – 2.15%) Mg (< 0.15% and Ti (<0.26%) values are generally low. Mean content of $A1_2O_3$ (14.9%). Na_2O, (3.5%) and K_2O (5.89%) compare favourably with the values of rare metal pegmatite occurrences across Nigeria (Okunlola, 2004). Trace element Rb (12ppm) Cs (1ppm) Nb. (17ppm) Ta (7ppm) Ga (20ppm) and Sn (1ppn) Li (14ppm) Be (5ppm) are significantly lower than averages for the rare metal pegmatites of Ijero-Aramoko, Kushaka-Birni Gwari, Oke Ogun, Ilesha-Osogbo, Isalu-Egbe, and Share, Nigeria (Okunlola, 2004), but are comparable to the Ilesha barren pegmatites (Elueze, 1982) and the Nasarawa, and Kafin Maiyaki barren pegmatites, (Garba, 2003). The Rb/Sr ratio is also low when compared to other rare metal mineralized pegmatites of Nigeria (Matheis and Emofurieta, 1987; Okunlola and Ocan 2002, Garba, 2003, Okunlola, 2004) but compares with the barren Nasarawa pegmatites (Garba, 2004). Average K/Rb values (780ppm) are also significantly higher than those of the rare metal pegmatites of Nigeria but are comparable with values of the barren pegmatites and granitoids (Kuster, 1990; Garba, 2003). The K/Rb vs Rb plot (Staurov, 1969) (Fig 3) which separates barren fractionation sequence and mineralized pegmatites, show the Itakpe pegmatite samples as plotting in the barren field, confirming the low degree of fractionation. This similar trend is also shown in the K/Rb vs cs plot (Fig 4). The degree of albitisation usually examined through the Na/k ratio (<0.86), reveals a low degree of albitisation. Sn, Nb-Ta mineralized pegmatites are usually higher than 1.0 in most cases (De Kun, 1965). This is also indicative of the degree of

Table 2: Results of Geochemical Analyses

	PS1	PS2	PS3	PS4	PS5	PS6	PS7	PS8	PS9	PS10	PS11
SiO_2	74.12	70.27	74.24	73.57	64.97	67.84	64.47	71.64	74.02	66.36	74.18
Al_2O_3	13.6	15.51	13.32	14.23	21.34	18.12	23.78	16.35	13.8	16.53	13.4
FeO	0.759	0.68	0.68	0.72	1.2	1.04	1.15	0.75	0.91	0.55	0.71
Fe_2O_3	0.844	0.89	0.89	0.93	1.33	1.16	1.27	0.84	1.02	2.29	0.79
CaO	2.15	2.25	1.19	1.06	0.15	0.91	0.05	0.95	0.99	2.24	1.8
MgO	0.14	0.15	0.1	0.08	0.12	0.08	0.07	0.05	0.07	0.05	0.08
Na_2O	3.61	4.75	3.53	3.28	4.38	4.88	2.47	2.37	2.08	1.25	0.86
K_2O	4.55	4.92	5.86	5.94	6.302	5.77	6.41	6.58	6.63	7.51	7.67
TiO_2	0.009	0.1	0.05	0.04	0.026	0.03	0.02	0.03	0.02	0.03	0.02
P_2O_5	0.04	0.04	0.04	0.03	0.032	0.018	0.013	0.02	0.014	0.002	0.02
SO_3	0.1	0.15	0.1	0.1	0.17	0.15	0.3	0.45	0.45	0.3	0.47
Li	14	16.4	11	13	7	7	6.8	8.9	9	14	22
Be	116	103.2	146	138	139	143	152	146	136	142	139
Cs	1.6	1.3	1	1	1	1	1.6	1.2	2	1	2
Ga	19.63	20.58	18	17	22	18	21.71	17.76	17.98	18.03	17
Be	2.1	3.3	5.3	2.4	3.2	2.1	5	6.2	3.4	2.2	3
Sn	1	1	1	2	0	1	0	1	1	2	3
Nb	2.96	3	1	1	1	1	1	1	1	1	[illegible]
Ta	3	2	5	6	4	4	3	5	6	7	9
Rb	123	113	115	127	125	111	120	121	105	104	108
Sr	501	493	499	680	485	490	479	489	691	683	491
Cd	<0.02	<0.02	0.03	0.02	<0.02	<0.02	0.04	<0.02	0.02	0.02	<0.02
Sb	0.16	0.12	0.26	0.33	0.48	0.31	0.28	0.11	0.21	0.18	0.16
Ag	36	40	43	47	45	38	37	42	53	54	35
Au	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zn	18	20	14	16	15	13	13	13	17	14	15
Co	2.6	2.3	1.6	0.5	3.6	2.8	2.6	1.8	1.9	2.4	1.8
Mn	73	85	76	67	58	63	56	72	68	71	69
V	12	9	13	16	11	12	14	13	8	14	13
As	1	1	1	1	2	2	1	1	2	2	1
Y	2	3	2	2	2	3	2	3	2	3	4
Eu	0.8	1	1	0	0	1	0	1	0	0	1
Ba	1102	1172	1012	817	798	928	956	1021	1036	996	1012
Zr	9.1	905	10.2	16.5	15,9	15.5	14.9	15.2	16.1	15.9	15.6
Sn	0.9	1.3	1.9	2.2	2.6	1.8	1.6	2.1	1.9	2.3	1.6
W	0.4	1.2	0.7	0.2	0.4	1.1	0.2	0.5	1.2	0.6	0.7
Sc	0.7	0.9	0.5	0.2	0.6	0.7	1.2	1.4	0.8	0.6	0.7
Cr	9.3	10	12.2	16	15.9	12.3	13.4	9.8	11.3	10.2	9.8
Mo	0.28	0.32	0.29	0.21	0.26	0.31	0.3	0.32	0.28	0.31	0.29
Cu	20.26	23.44	21.36	16.69	17.89	20.32	23.41	22.78	23.51	23.96	24.1
Pb	30.6	34.27	32.4	33.1	31.26	33.42	31.62	32.4	31.63	30.36	31.42
Th	1.4	1.8	1.6	1.9	2.1	2.2	1.7	1.9	1.8	2	2.8
U	0.3	0.7	0.3	0.4	0.6	0.4	0.5	0.8	0.9	0.7	0.6
As	1.7	1.8	1.6	1.2	1.5	1.6	1.5	1.4	1.6	1.8	1.7
Ni	9.2	10.2	5.3	1.7	3.6	2.4	4.6	5.2	6.3	7.1	8.2
Bi	0.04	0.06	0.06	0.07	0.05	0.04	0.05	0.06	0.08	0.09	0.08
Sb	0.36	0.12	0.29	0.33	0.26	0.29	0.28	0.31	0.32	0.3	0.31
Cu	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ce	17.26	18.74	16.84	12.22	13.2	14.3	15.36	16.26	14.2	15.36	12.36
Dy	0.7	1	0.8	0.6	0.5	0.7	0.8	0.9	1	0.8	0.6
Er	0.7	1	0.8	0.6	0.5	0.7	0.8	0.9	1	0.8	0.6
Tm	0.1	0.1	0.2	<0.1	0.1	0.2	0.3	0.1	0.2	0.3	0.2
Yb	0.3	0.5	0.3	0.4	0.3	0.4	0.5	0.4	0.6	0.4	0.3
Ho	0.1	0.2	0.3	0.1	0.2	0.3	0.1	0.2	0.3	0.3	0.4
Tb	0.1	0.2	0.2	0.1	0.4	0.3	0.5	0.2	0.4	0.3	0.1
Hf	0.39	0.42	0.41	0.46	0.49	0.53	0.52	0.48	0.51	0.46	0.43
K/Rb	325.5	395.3	332.8	357.2	363.2	392.5	350	364.3	403.8	438.73	456.6
K/Cs	23525	31384	27000	35214	27526	31277.7	33250	45500	25000	36647	31800
K_2O/Na_2O	1.26	1.035	1.67	1.81	1.439	1.18	2.6	2.77	3.19	6	8.91
Rb/Cs	72.5	79.4	81.1	98.6	98.5	73.3	79.6	95	121.6	61.9	69.65
Nb/Ta	0.94	1.13	0.32	0.24	0.26	0.22	0.304	0.27	0.242	0.24	0.27
Rb/Sr	0.23	0.209	0.29	0.2	0.286	0.29	0.32	0.3	0.29	0.2	0.28
Na/K	0.71	0.86	0.54	0.49	0.62	0.64	0.34	0.32	0.32	0.15	0.1
Ba/Rb	9.7	11.3	6.9	5.9	5.7	6.5	6.2	7	7.6	7	7.6
Rb/Cs	72.5	79.4	81.1	98.6	98.5	73.3	79.6	95	121.6	61.9	69.6

Table 3
REE / Chondrite Normalized Data of Itakpe Pegmatites

	PS1	PS2	PS3	PS4	PS5	PS6	PS7	PS8	PS9	PS10	PS11
La	2.72	2.71	2.65	2.63	2.73	2.52	2.63	2.76	2.77	2.65	2.68
Ce	15.54	16.87	15.16	11.7	13.8	12.87	12.8	14.63	12.17	13.82	11.7
Nd	3.8	2.4	2.6	3.2	3.6	3.5	3.6	3.2	3.5	3.5	3.7
Sm	.26	.16	.24	.23	.20	.18	.18	.21	.26	0.26	0.28
Eu	.09	.05	0.09	0.08	0.06	0.09	0.08	0.08	0.09	0.01	0.08
Gd	.23	0.16	0.17	0.28	0.15	0.16	0.18	0.18	0.19	0.18	0.20
Tb	.009	.010	.009	.005	.006	.005	.006	.007	.008	0.009	0.009
Dy	0.30	.18	.30	.25	.18	.17	.16	.28	.29	0.28	0.28
Ho	.002	.007	.004	.009	.002	.003	.004	.008	.004	.004	.005
Er	0.1	0.08	.08	0.09	0.09	0.12	0.10	0.06	0.08	0.1	0.08
Tm	0.003	0.003	0.004	0.002	0.003	0.005	0.003	0.002	0.002	0.003	0.04
Yb	0.1	0.08	0.08	0.08	0.1	0.18	0.08	0.06	0.07	0.1	0.08
Cu	0.04	0.06	0.08	0.09	0.05	0.05	0.06	0.04	0.04	0.05	0.04

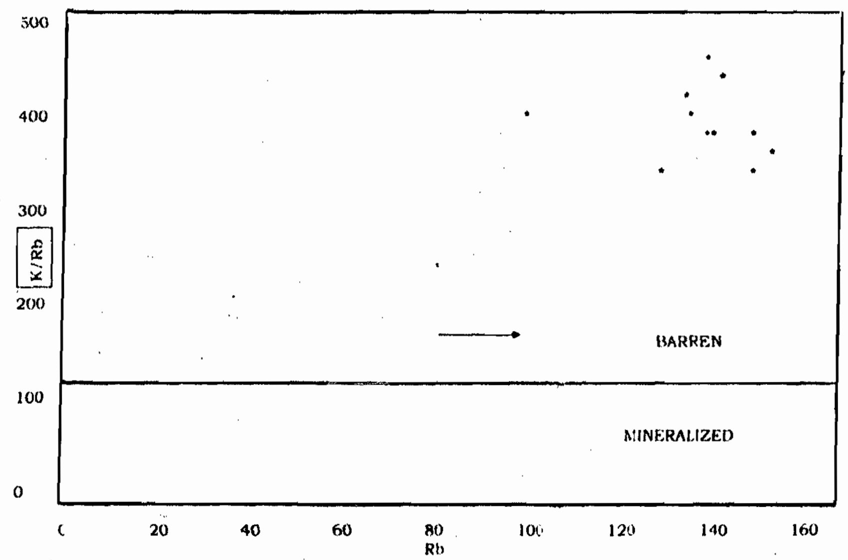

Fig: 3 K/Rb vs Rb distribution pattern in the Itakpe pegmatites arrow indicates normal differentiation trend after Staurov et al (1969)

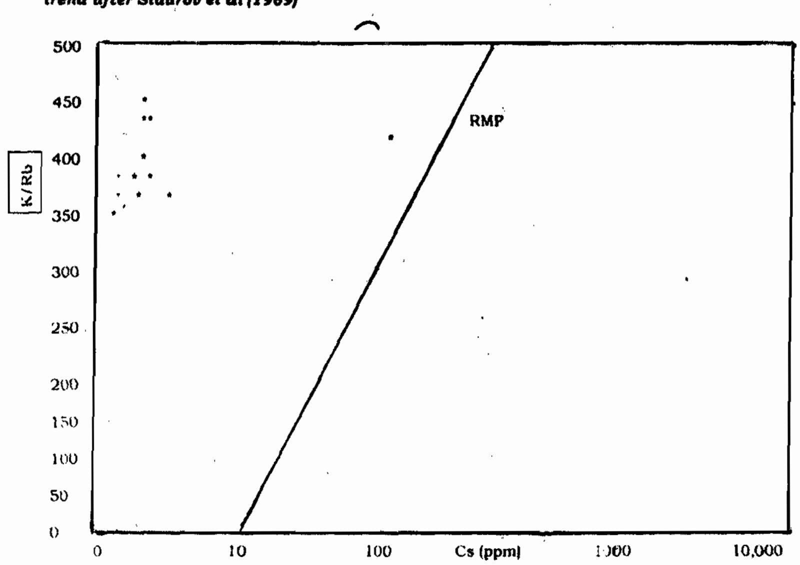

Fig4K/Rb vs Cs Plot of the Itakpe Pegmatites

Discrimination line separates the field of rare metal pegmatites from the barren class. (Adapted from Cerny, 1982 and Morteani et al, 2000).

fractionation. Ba/Rb ratio which is usually applied as an index of differentiation (Rhodes, 1975) ranges between 5.7 – 9.7 for the Itakpe pegmatites and show poorly fractionated parent magma. This is no contrast to values obtained for the Ta-Nb highly fractionated mineralized pegmatites from other pegmatite fields. (Okunlola, 2004; Garba, 2003) Zr/SiO_2 (Fig.5). Plots also reveal metamorphic origin for the pegmatites. A further evaluation of level of mineralization and thus fractionation using the Ta vs. Cs, Be/K/Nb, Ta vs. Nb and Ta vs. K/Cs plots (Figs. 6,7,8,9) shows that the samples plot far below the boundary of mineralization (Gordiyenko, 1971; Beus, 1966) and also far blow other rare metal pegmatites from across the world.

Rare earth element fractionation trends of the pegmatites as defined by Ce anomalies observed for the mineralized pegmatites of Northern Nigeria (Garba, 2003). Negative Ce anomalies of rare metal pegmatites is taken to be indicative of oxidizing conditions during mineralization and involves possible interaction between magmatic and melt fluids and host rocks over sometimes long distances (Graft, 1977, Piper, 1974; Curlet et al, 1974; Garba, 2003). The absence of this trend in the samples of the Itakpe pegmatites rules out the role of late stage or metasomatic fluids in the genesis of these rocks. This further confirms minimal or lack of metasomatic alternations or extensive post magmatic differentiation in their emplacement. This might also mean a close proximity of

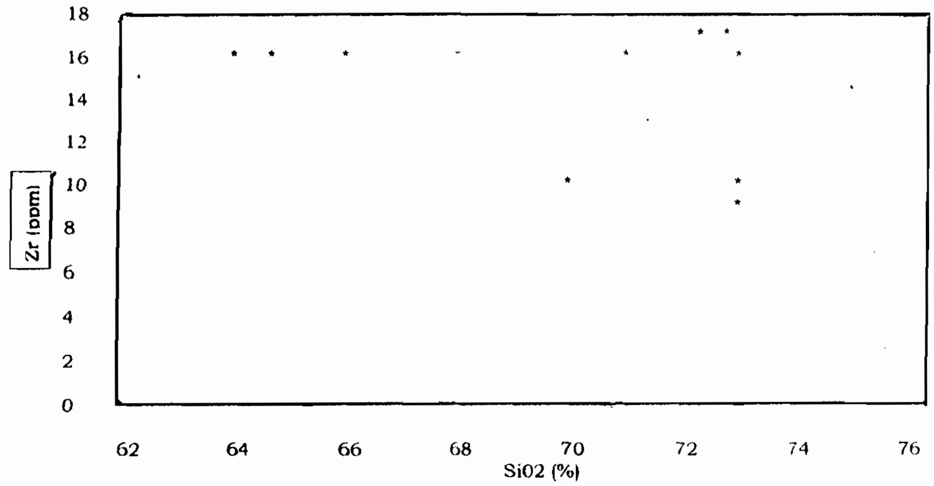

Fig:5 Zr vs SiO2 plot of the Itakpe Pegmatites

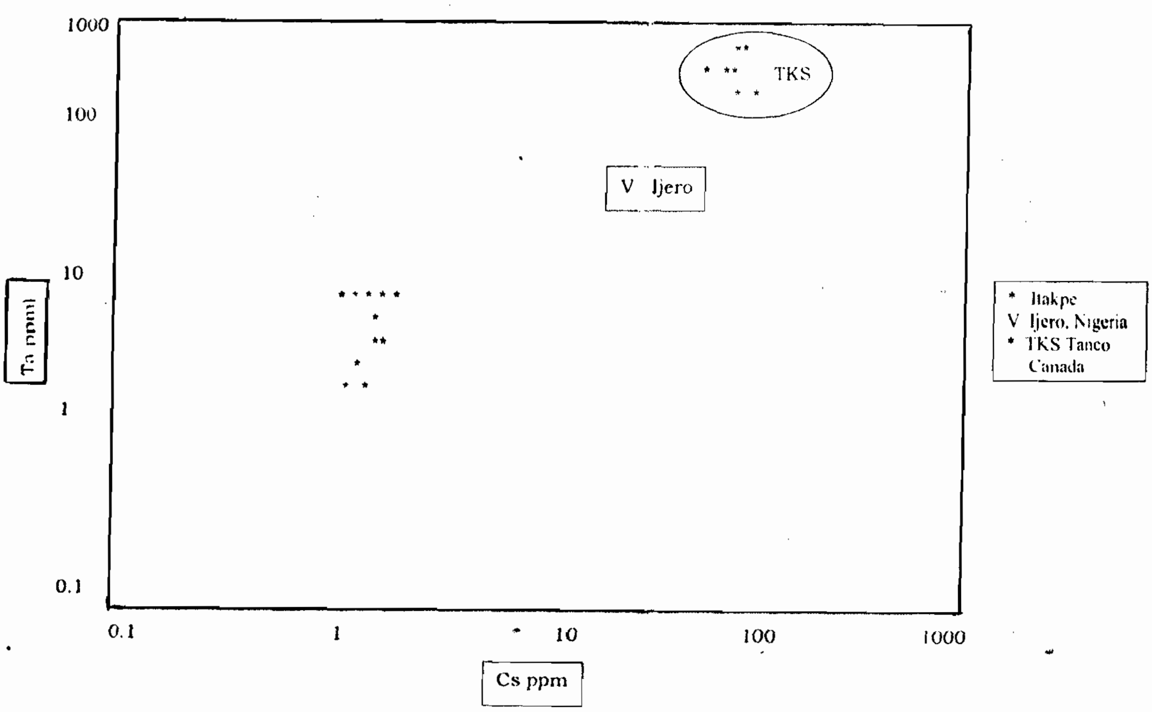

Fig:6 Comparative Ta vs Cs plot

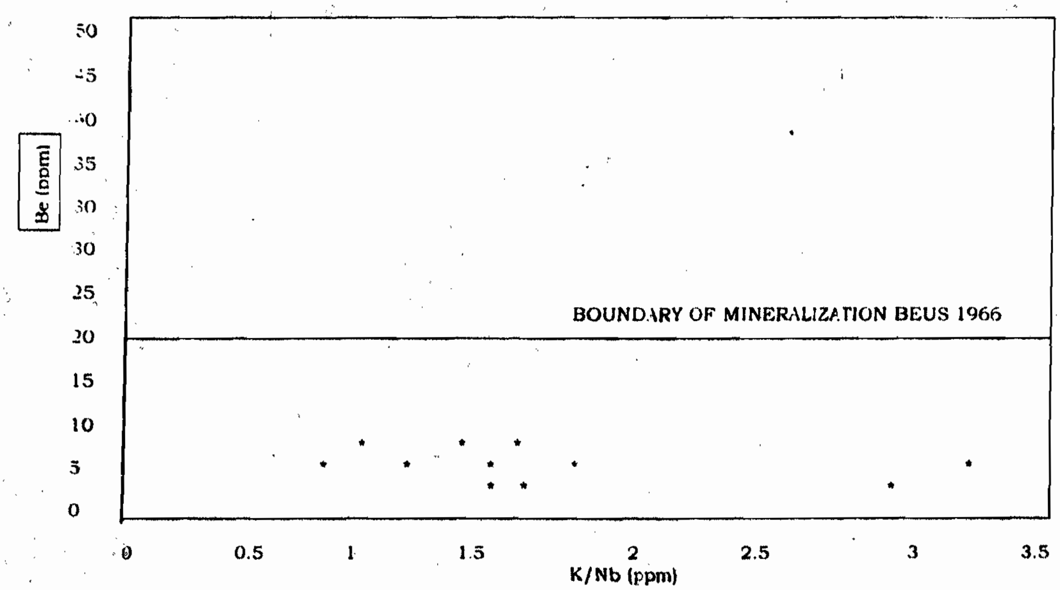

Fig: 7 Be vs K/Nb distribution pattern of Itakpe pegmatites

The Itakpe pegmatites fall below the boundary of mineralization i.e. Be > 20 (Beus, 1996).

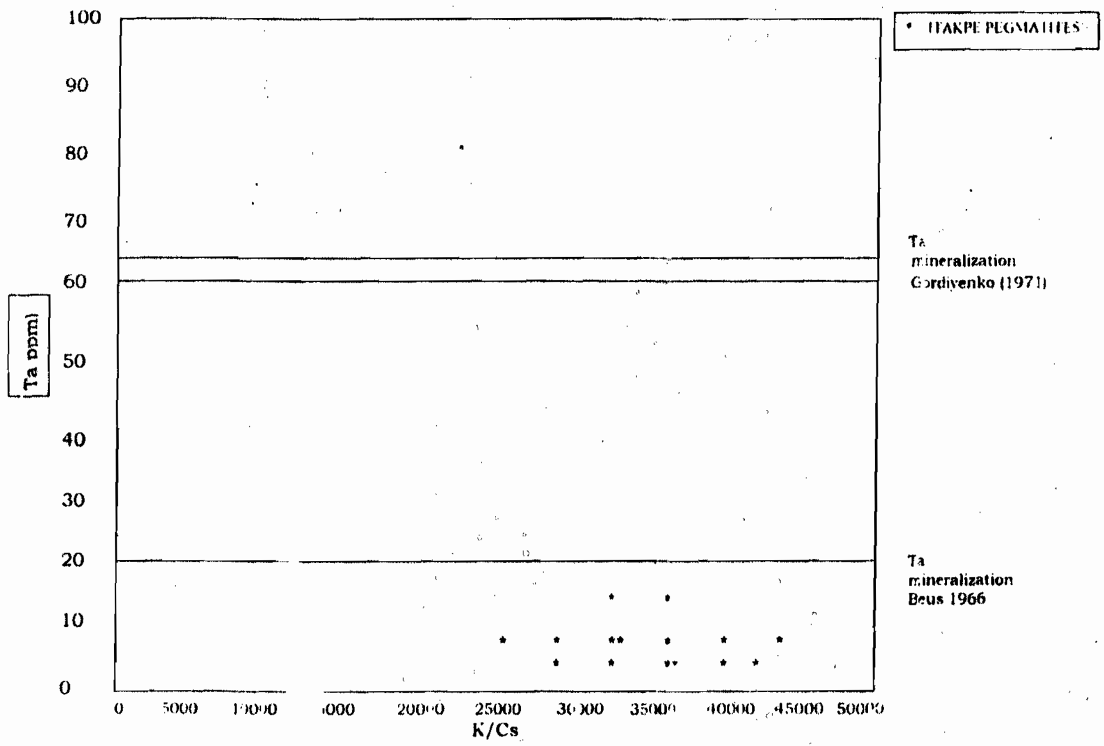

Fig:8 Plot of Ta vs K/Cs to determine tantalum potential of Itakpe pegmatites

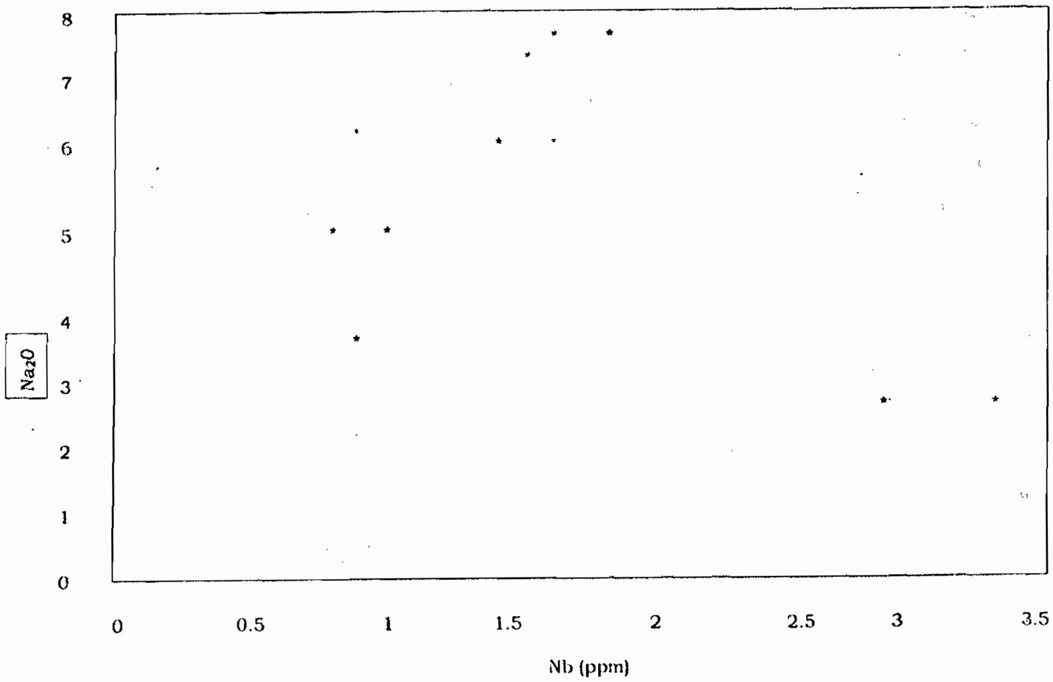

Fig: 9 Ta vs Nb plot for the Itakpe pegmatites

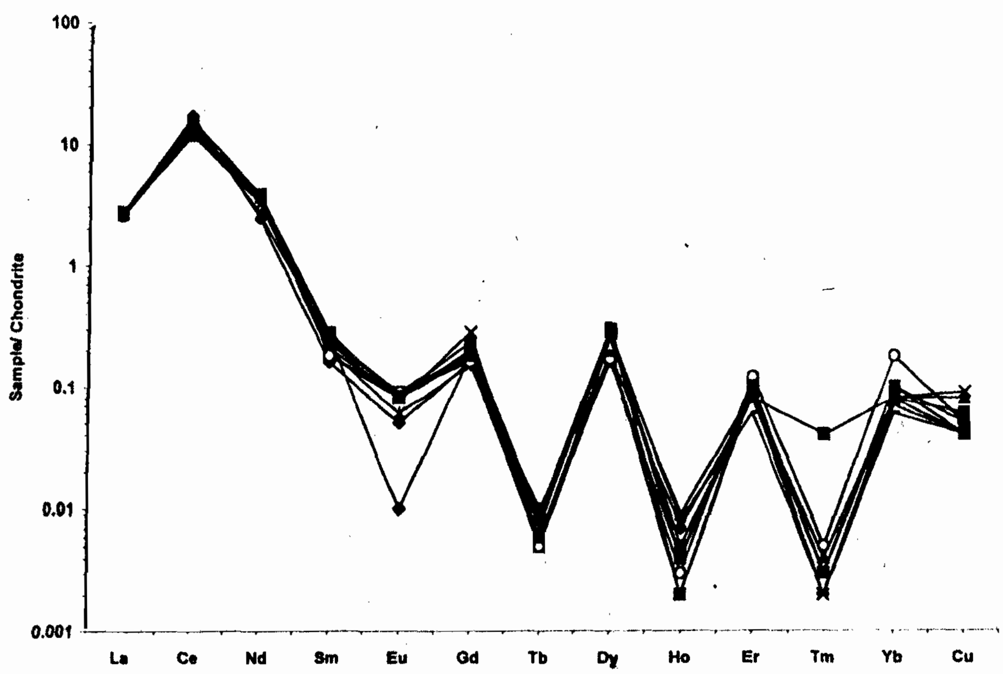

Fig:10 Rare earth elements Chondrite - normalised plots for samples of Itakpe pegmatites

emplacement to their parent melt sources. Furthermore, the Rb/Sr crustal thickness Plot (Condie, 1976) (Fig 11) shows that the basement around Itakpe attained a thickness of more than 30km during replacement of this pegmatites. Considering the apparent stability of the Nigerian sector subsequent to the Pan African event, it is inferable that the crust in the region attained substantial thickness during Proterozoic times.

CONCLUSIONS

Near vertical dipping coarse gained pegmatite veins occur associated with the gneisses, Schists and Banded iron formation around Itakpe area, central Nigeria. Petrographic determinations show they are enriched in Microcline and quartz and to a lesser extent in Plagioclase albite with interstitial muscovite and accessory biotite. Geochemical studies reveal that they are poorly fractionated. This shows nearness, to their parental melt sources or metamorphic progenitors. Rare metal indicative elements Ta, Nb, Rb, Cs, Sn are depleted in the rock unit while elemental ratio, K/Rb, Ba/Rb suggest low index of differentiation, poor fractionation

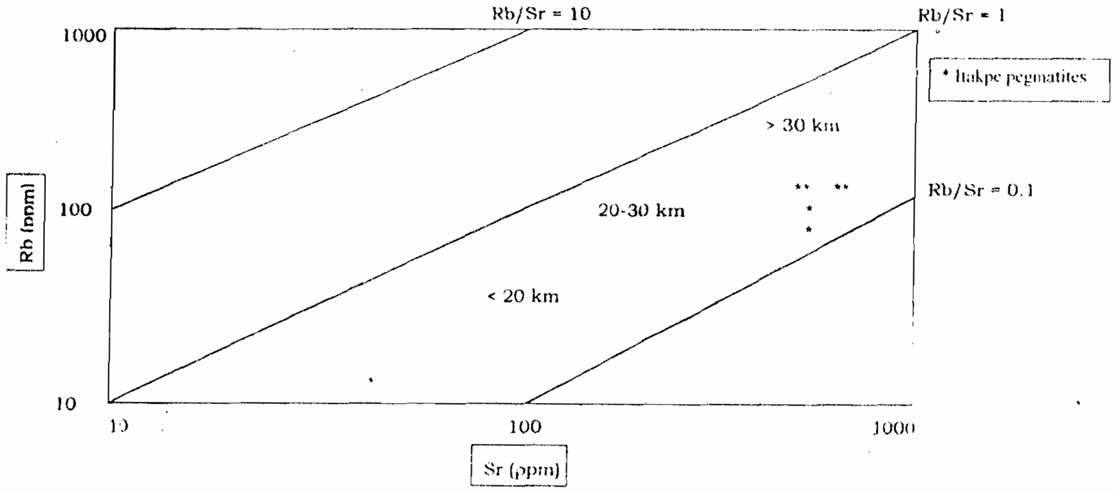

Fig:11Rb vs Sr Diagram of Itakpe pegmatites

and barren mineralization. Poor albitization is demonstrated in the Na/K ratio while Ta Vs Cs, Ta Vs Rb, and Ta Vs K/Cs confirms its apparently poor or barren mineralization compared to other pegmatites bodies in Nigeria and else where in the world.

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