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Geochemistry of Weathered Profiles over Syenite and Younger Granite in Pankshin Area, North Central Nigeria

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Abstract

Metallic ores of economic values often occur within profiles above basement rocks in tropical regions due to weathering and secondary enrichment. This study is carried out to determine the geochemistry and appraise the potential for metallic ore enrichment in the weathered profiles over Syenite and Younger Granite in Pankshin area. Top-soil, laterite and rock samples are collected from two lateritic profiles above Syenite and Younger Granite. The syenite rock is composed of alkali feldspars (perthite), nepheline, clinopyroxene, with minor amount of orthopyroxene, hornblende, plagioclase and few quartz grains, indicating oversaturation. The Younger Granite contains plagioclase feldspars, microcline, quartz, biotite, hornblende and reibeckite. Quartz (61.0%), kaolinite (32.0%) and microcline (7.0%) are the dominant minerals in the X-ray diffraction (XRD) of the decomposed rocks. The Chemical Index of Alteration (CIA) of both rocks is generally >90. There are enhancements of V, Sc, Zr and TiO_2 in the Syenite profile and Fe_2O_3, Zr, V and TiO_2 in the Younger Granite profile as reflected in the Accumulation Factor (AF), loss and gain of elements (K), though the values were too low for ore mineralization except for iron and titanium in the Younger Granite profile.

Keywords: geochemistry, Syenite, Younger Granites, laterite, Pankshin

1. Introduction

The chemical compositions of laterite within a soil profile vary according to the nature of the rock. Laterites are usually rich in mineral deposits such as aluminium, manganese, nickel, chromium and cobalt (Fox, 1923; Valenton, 1972; Golightly, 1981; Schellmann, 1981; 1983; 1989; Maignien, 1966). Pankshin area in the north central part Nigeria (Figure 1) is underlain by migmatite, granite gneiss, basalt, Syenite and Younger Granite (Figure 2). The Younger Granite around Jos plateau is noted for tin, niobium and tantalum occurrences. Previous studies in the area are mainly on the tin-bearing Jurassic Younger Granites (Macleod, 1971; Turner, 1989) with little attention on the residual profiles over other rock types (Du Preez, 1956; Tietz, 1983; Matheis, 1983; Valeton & Beissner, 1986; Zeese, 1991; Bernhard & Tietz, 1997).

Weathered profiles over Syenite and Younger Granite are examined in this investigation. Metallic ores of economic values often concentrated within lateritic profiles above basement rocks in tropical regions due to supergene enrichment. This study is carried out to determine the geochemical characteristics of the lateritic profiles over syenite and Younger Granite in Pankshin area in order to appraise their economic potentials in terms of metallic ore enrichment.

2. Location and Description of the Weathered Profiles in the Study Areas

Profile 6 is overlying Syenite on the eastern side of Pankshin town (Figure 2). The Syenite occurs as intrusions within granite gneiss. A 3m thick profile is exposed in an abandoned laterite quarry at the back of the Local Government secretariat in Pankshin. Three horizons are identified based on their colour, textures and structures. They are the top soil, the laterite zone and the saprolite (Figure 3). The thin brownish top soil layer is 0.2 to 0.5m thick. It is rich in quartz and organic matter. The light brown laterite zone extends to a depth of about 2.5m, where it makes gradational contact with the saprolite zone as shown in Figure 3. The saprolite layer is pale yellow in colour with the textural characteristics of the parent rock well preserved.

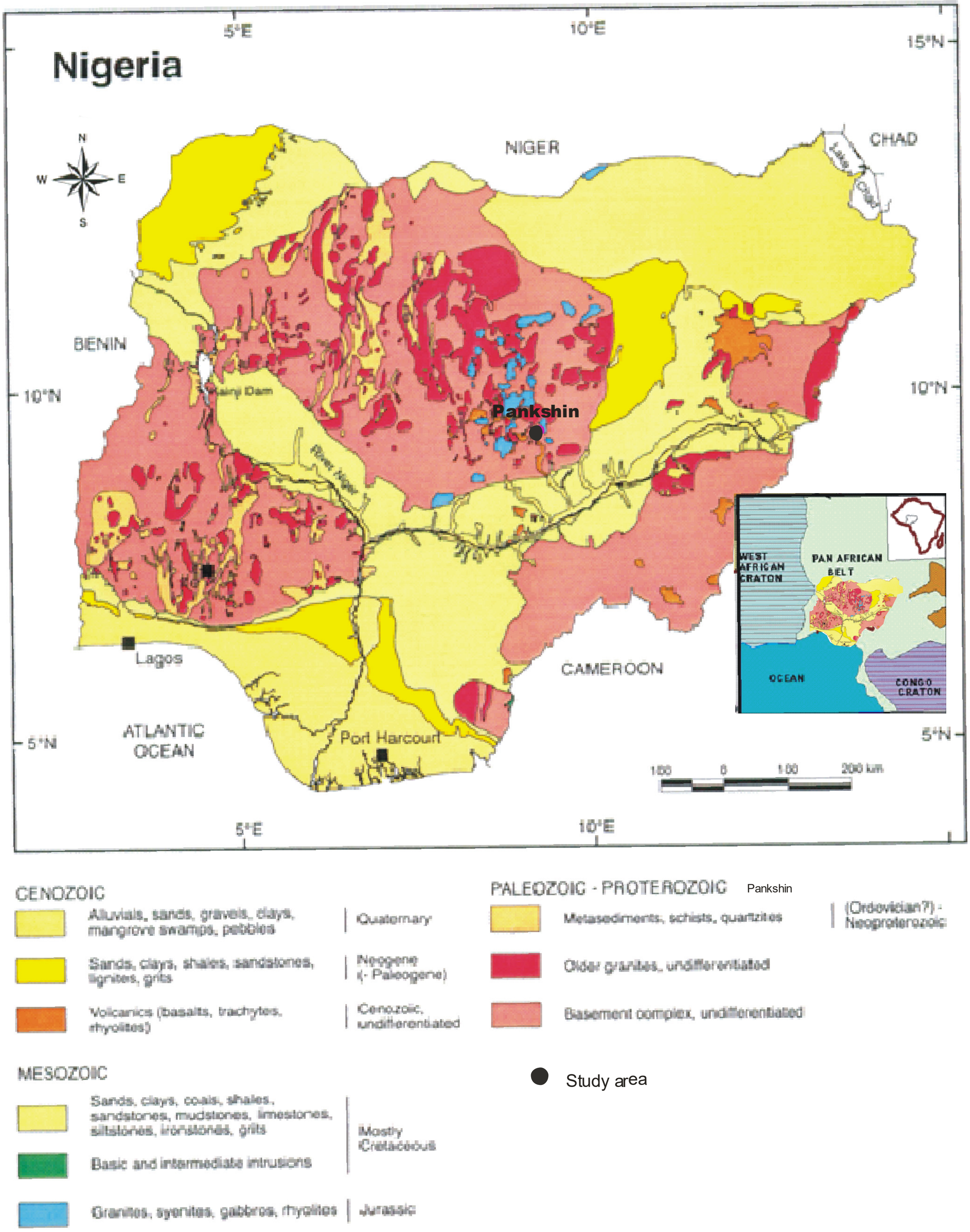


Figure 1. Geological map of Nigeria showing the location of Pankshin area (After Nigeria Geological Survey Agency, NGSA, 2004)

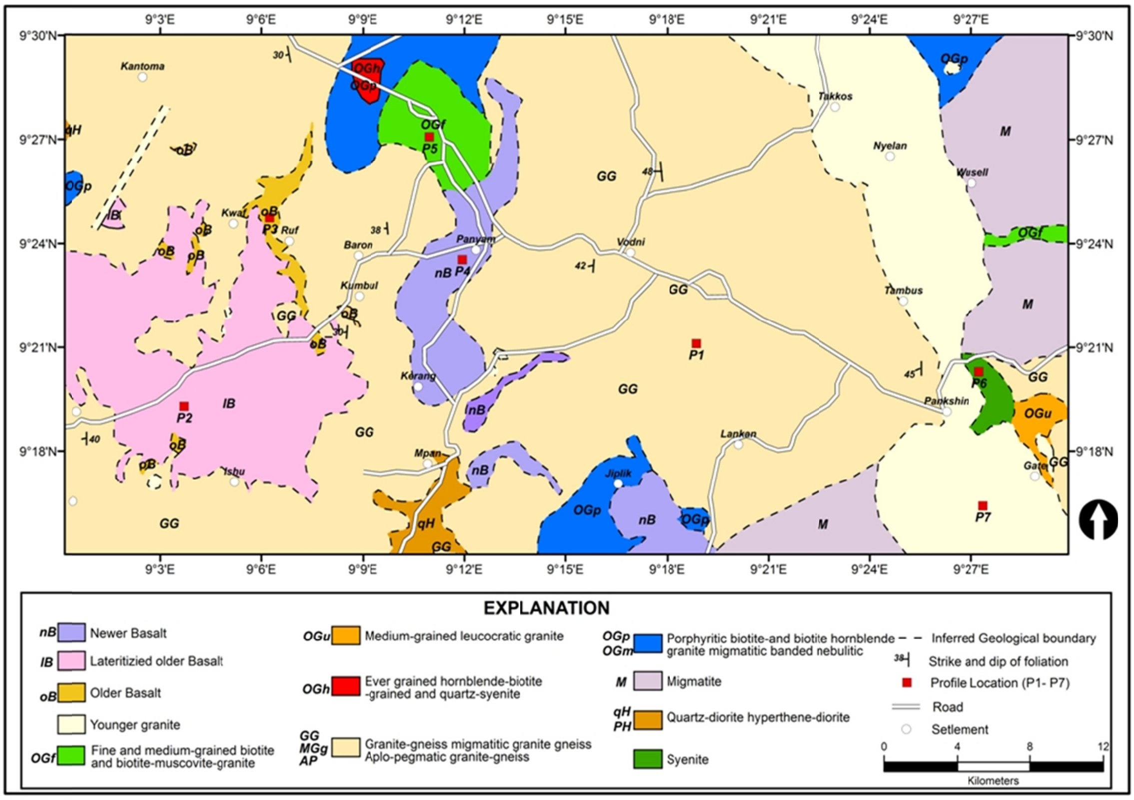


Figure 2. Geologic map of Pankshin and its environs (Modified after Nigeria Geological Survey Agency, NGSA, 2004)

Profile 7 above the Younger Granite also occurs at the eastern side of Pankshin town (Figure 2). The profile is in a pit within the premises of the Local Government secretariat at Pankshin (Figure 4). Three horizons, similar to those on the Syenite occur in the Younger Granite. The horizons are classified according to their colour, texture and presence of relic structures. The average thickness of each layer is about 1.4m. The saprolite zone could not be fully penetrated because it was very hard and tough. Pegmatite dykes cut across the Younger Granite as observed in the weathered profile (Figure 4).

3. Method

Geological field mapping of the area is carried out on a scale 1:25,000. Twenty six samples comprising 11 of rocks, 7 of laterite and 8 of top soil are collected from two lateritic profiles above Syenite and Younger Granite in Pankshin area. Sampling interval along the vertical section of the profile is 50 cm. The parent basement rocks are collected from the base and outcrops around the profiles.

Petrography is carried out on thin sections of the study rocks. Semi-quantitative and qualitative analyses of powdered rocks, laterite and top-soil samples are undertaken with a Philip PW1800 X-ray diffractometer using Cu K Alpha radiation. Elemental compositions of the rocks, laterite and top-soil samples are determined using inductively coupled plasma-mass spectrometer (ICP-MS). Both XRD and chemical analyses are carried out at the Activation Laboratories, Canada. The diffraction peaks obtained are compared with well established standards and interpreted with reference to JCPDS (1974) diffraction file. Quantitative estimation of the respective minerals is also carried out by computing the peak areas of their reflection intensities. Chemical Index of Alteration (CIA), Accumulation Factor (AF), loss and gain of elements (K) are calculated from the elemental data to determine the intensity of weathering and metallic ore enrichment. The metal accumulation factor and the loss and gain of element upon weathering is calculated according to the method of Minarik *et al*., (1983). Enrichment (gain) or depletion (loss) is calculated from the concentration of the element under consideration (in oxide wt. %), after normalization (Nesbitt et al., 1980; Middelburg et al., 1988; Van der Weijden & Van der Weijden, 1995).

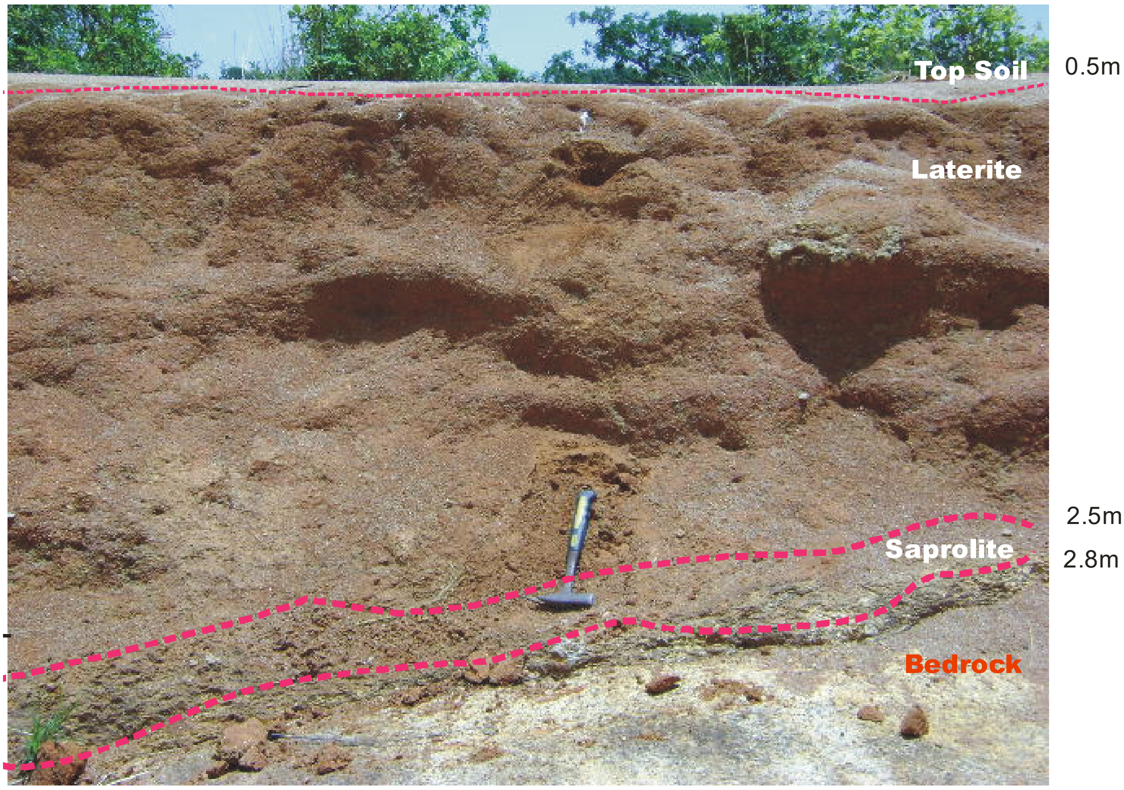


Figure 3. Weathered profile above Syenite (Profile 6) in Pankshin area

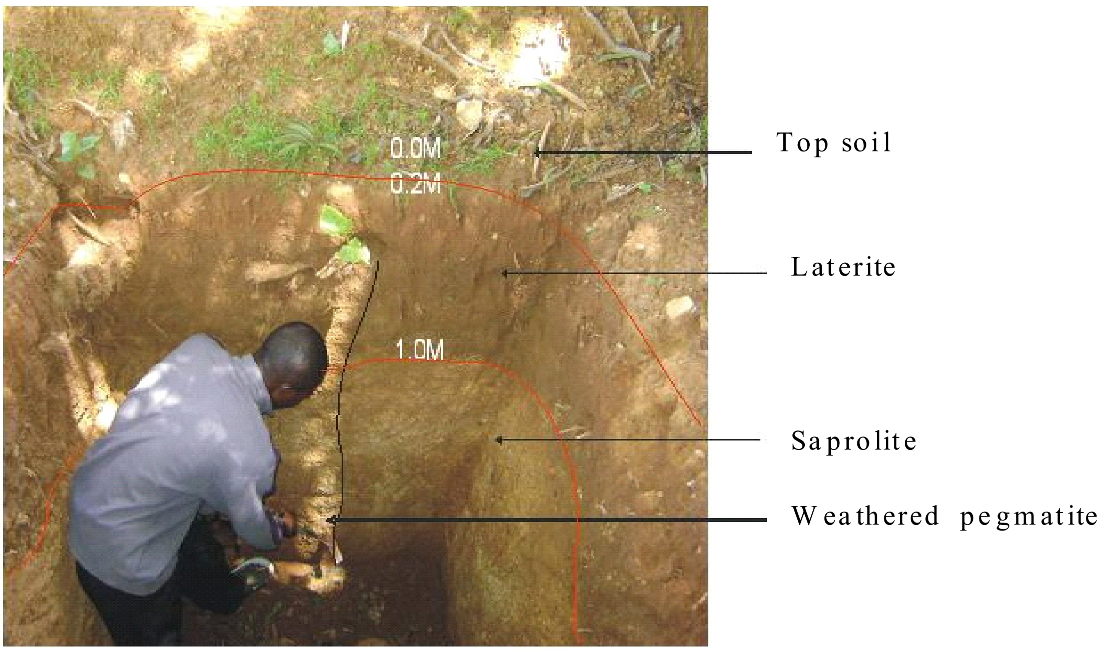


Figure 4. Weathered profile above Younger Granite (Profile 7) in Pankshin area

4. Results and Discussion

4.1 Petrography

Syenite occurs as low-lying hills and ridges at the southeastern part of Pankshin town (Figure 2). It is grey in colour, medium to coarse grained without any evidence of deformation. The common variety at the eastern part of Pankshin is coarse and even grained. The rock is composed of alkali feldspars (perthite), nepheline, clinopyroxene, with minor amount of orthopyroxenes, bluish green hornblende, plagioclase and few quartz grains (Figure 5), indicating oversaturation. Epidote, biotite, apatite and opaque minerals occur in accessory quantity. The mineral grains are generally euhedral to sub-euhedral.

The Younger Granite is one of the most abundant rock types in the area covering about three quarters of the northeastern to the southeastern part. Most of the steeply inclined conical hills around Pankshin town are Younger Granite outcrops. The outcrops are on the average 2000m high above sea level. The rock is grey in colour and medium to coarse grained in texture. The Younger Granite contains feldspar, quartz, biotite, hornblende and reibeckite. The rock is porphyritic with plagioclase occurring as phenocryts within quartz matrix (Figure 6).

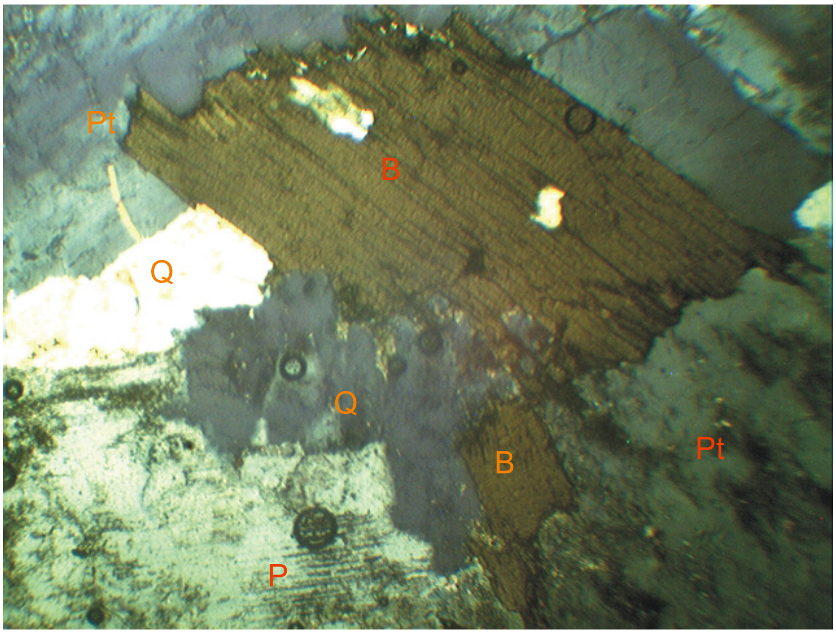


Figure 5. Photomicrograph of Syenite showing porphyroblasts of biotite (B) with inclusions of quartz (Q) surrounded by perthite (Pt) and plagioclase feldspars (P) (Cross polars x 4)

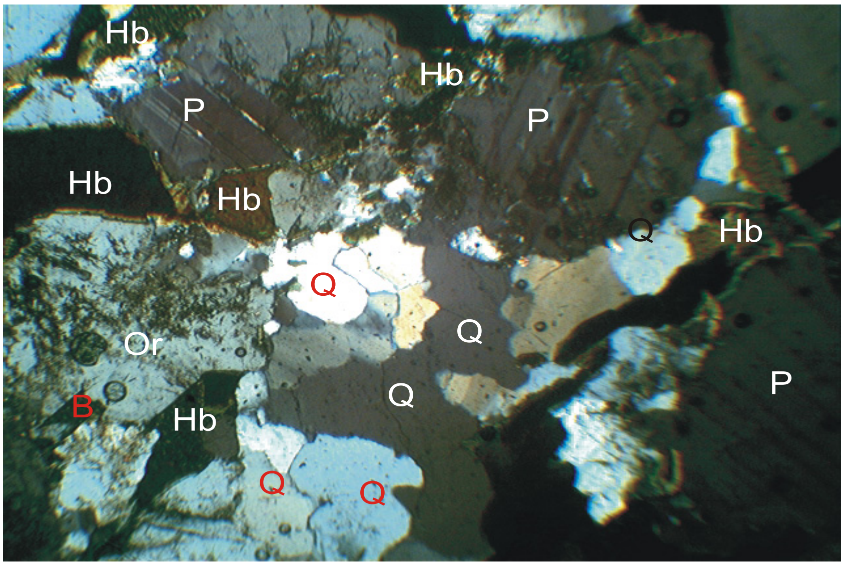


Figure 6. Photomicrograph of Younger Granite showing phenocrysts of plagioclase (P) in quartz (Q) and hornblende (Hb) matrix (Cross polars x 4)

4.2 Mineralogy

The XRD of the soil and the laterites over Syenite (Figures 7a and 7b) show prominent peaks of kaolinite, microcline, and quartz. Bauxite minerals are often generated from the weathering of Syenite occurring in plateau regions, notably in India, Brazil, Australia and Arkansas in the United States of America. The dearth of bauxite minerals in the profiles around Pankshin could be attributed to the ruggedness of the terrain, which aided run-off and may not permit upward and downward alternate movement of the water table. The trend of weathering within the profile is towards iron enrichment (lateritization) rather than the expected aluminium accumulation (bauxitization) (Aleva 1994; Bolarinwa 2001 and 2006).

The X-ray diffractograms of soil and laterite on the Younger Granite are illustrated in Figures 8a and 8b. They show prominent peaks of kaolinite, quartz, microcline, albite and muscovite. The presence of muscovite, albite and microcline in the weathered profile indicate incipient chemical weathering. With abundant sodic feldspars, biotite and amphiboles in the primary rock, the obvious end product of chemical weathering of such minerals in a well drained area, such as Pankshin is kaolinite. In weathering, topography and time is very important. The inability of the location to retain water for a period of time due to the nature of the slope could be partly responsible for the thin profile.

4.3 Geochemistry

The chemical compositions of the weathered profile over Syenite at Pankshin are presented in Table 1, while the average and range values are presented in Table 2 and Figure 9. The average contents of $Fe_2O_{3(t)}$ increased from 2.34% in the rock to 4.49%, and 4.94% in the laterite and soil; respectively (Table 2). The decrease in CaO, Na_2O and K_2O average contents from the bedrock to the soil is due to leaching of these oxides whereas, TiO_2 content slightly increases from 0.11% in the rock to 0.60% in the laterite. The total MgO + CaO average values are 2.13% in the rock and 0.27 and 0.12% in the laterite and soil layers. The $Na_2O + K_2O$ content are 8.84 in the rock, 1.58 and 0.87 in the laterite and soil respectively (Figure 9). This conforms to the normal trend in chemically weathered rocks in tropical regions (Mattheis 1983, Hallberg 1984 and Middelburg et al 1988). Average concentration of Ba (1179, 130, 159) ppm, Sr (206, 22, 22) ppm, Y (249, 58, 58) ppm and Be (5, 2, 2) ppm show depletions from bedrock through laterite to soil. On the other hand Sc (3, 6, 7) ppm and Zr (384, 594, 626) ppm increases from bedrock through laterite to soil. The absolute concentration of V in the rock (11 ppm) is lower compared to those of laterite (53 ppm) and soil (62 ppm). The silica-sequioxide ratio (SR) of the laterite (4.24) and soil (3.65) and the corresponding alumina-iron oxide ratio (AR) of 4.26 and 2.92 strongly suggest that the soil, which is produced from the weathering of Syenite, is non-lateritic according to the classifications of Nesbitt & Young (1984) and Aleva (1994).

Major and trace elements concentration in the profile over Younger Granite are presented in Tables 3 and 4. SiO_2 content decreases from 72.76% in the bedrock to 37.60% in the laterite and 48.42% in the soil (Table 4). Al_2O_3 increased from 14.54% in the bedrock to 22.20% in the laterite, whereas Fe_2O_3 content increases from 1.37% in the bedrock to 22.30% in the laterite and decrease to 20.55% in the soil due to leaching of the top soil. Iron bearing rock-forming minerals notably hornblende, biotite and ilmenite commonly release iron oxides/hydroxides during chemical weathering. Trace element data in Tables 3 and 4 show notable increment of Y (11 to 39 ppm), Zr (55 to 810 ppm) and V (26 to 242 ppm) from bedrock to the laterite. Other trace elements: Ba (537-260 ppm) and Sr (293-70 ppm) show depletion from bedrock to laterite.

Silica Ratio of the laterite (0.93) and soil (1.46) and the AR of 1.31 and 1.30 for the laterite and soil (Table 4) can be used to determine the types of soil formed from the chemical weathering of the parent rocks. According to Martin & Doyne (1927) and Nesbitt & Young (1984, 1989), true laterite is assigned a ratio of 1.33; lateritic soil 1.33 to 2.0 and non lateritic soil >2.00. Results from Tables 2 and 4 showed that the soil formed from Younger Granite with SR ratio of 1.46 is lateritic, while Syenite with 3.61 is non lateritic. The SR and AR values in this study strongly suggest that true laterite is produced only from the weathering of the Younger Granite. This is similar to results obtained by Nesbitt & Young (1984) and Aleva (1994). The total values of alkalis (MgO + CaO) is 1.77 in the rock and 0.40 and 0.21 in the corresponding laterite and soil, whereas the average values of ($Na_2O + K_2O$) is 8.07 in the rock, 0.16 and 1.03 in the laterite and soil respectively; thus indicating strong leaching of the regolith. The dominance of iron bearing minerals such as goethite and heamatite in the lateritic profiles and the high Fe_2O_3 concentration in the chemical data suggests that the trend of weathering is towards iron enrichment (lateritization) and not aluminium enhancement (bauxitization).

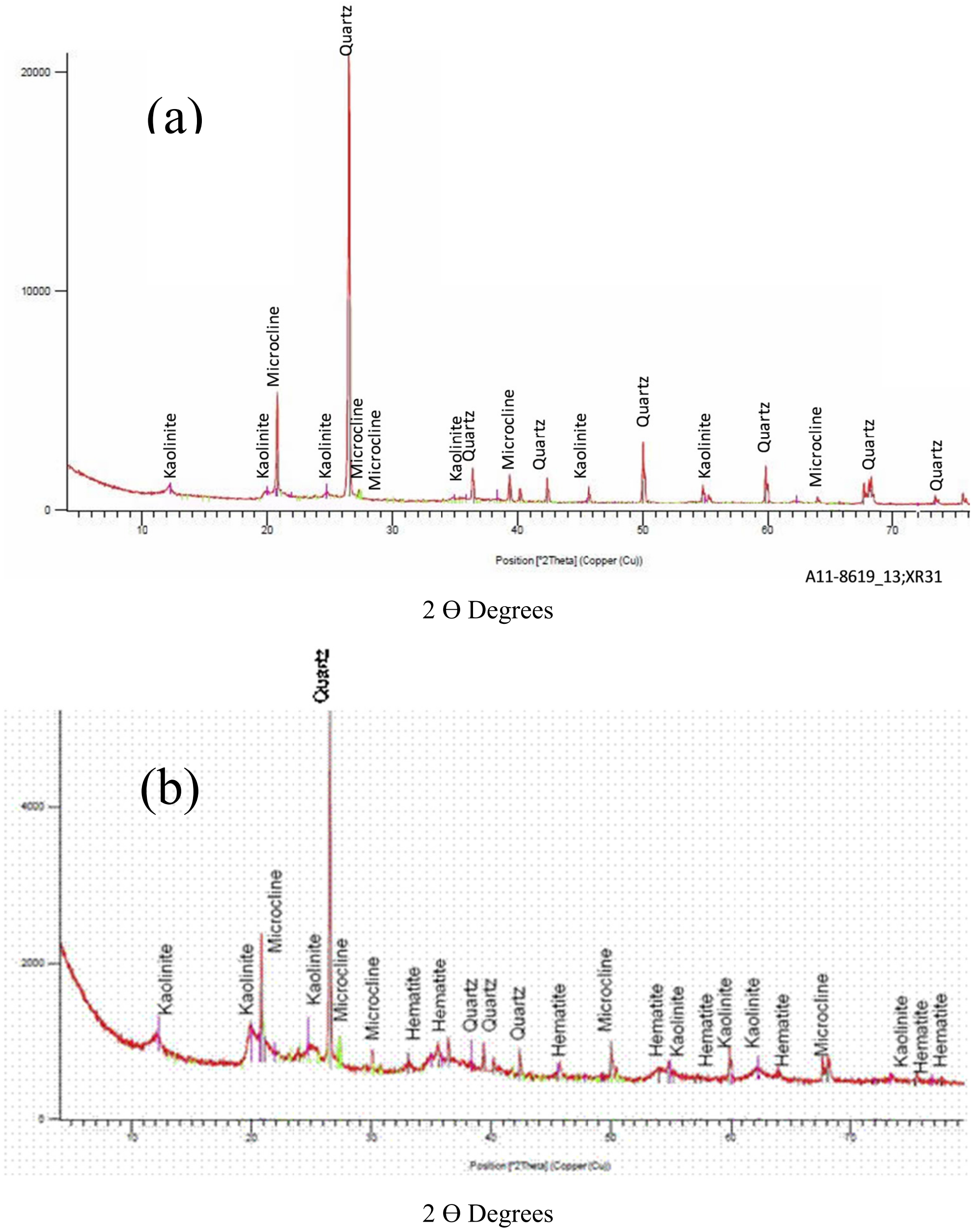
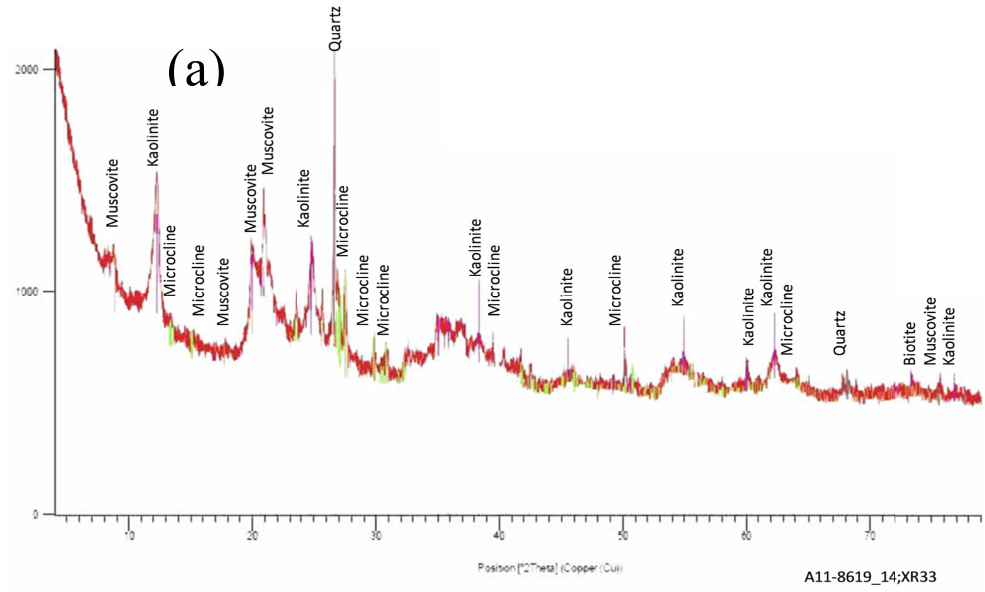
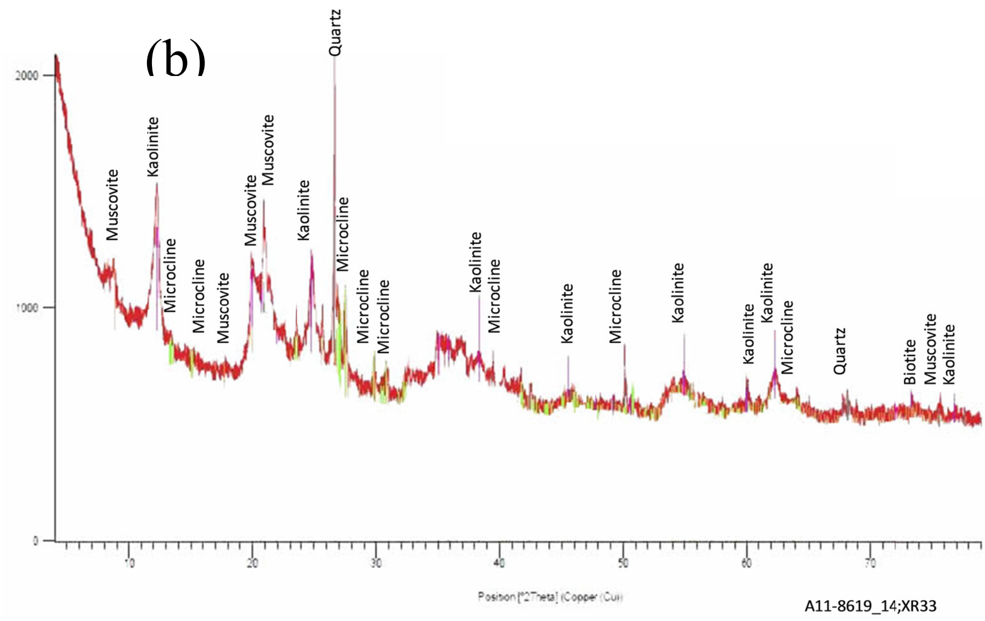


Figure 7. X-ray diffraction of (a) soil and (b) laterite developed on Syenite in Pankshin area



2 Θ Degrees



2 Θ Degrees

Figure 8. X-ray diffraction of (a) soil and (b) laterite on Younger Granite in Pankshin area

4.4 Chemical index of Alteration (CIA) in the Study Profiles

Chemical Index of Alteration (CIA) is used to measure the intensity of weathering for soils and sediments. This parameter is derived by Nesbitt & Young (1982, 1984), modified by Maynard (1992) as the K_2O-free CIA, or CIA-K. Intensity of Chemical Weathering (ICW) is not used in this study because ICW does not account for the aluminium associated with K-feldspar and so may yield very high values in K-feldspar rich rock, whether they are chemically weathered or not (Fedo et al., 1995, 1997). CIA is essentially a measure of the extent of conversion of feldspars to clays. Therefore, the CIA value is a good indicator of the extent of chemical weathering experienced by a parent rock (Nesbitt & Young, 1982, 1984, Anupam & Rajamani, 2000). The CIA values presented in Tables 1, 2, 3 and 4 show advanced stage of weathering in both the Syenite and the Younger Granite contrary to the mineralogical data which indicate incipient weathering notably in the Younger Granite. The CIA value for Syenite profile vary from 88.24% in the laterite to 92.60% in the soil, which indicate lower intensity of weathering compared to that of the laterite above the Younger granite with 97.32% and 91.20% for the laterite and soil layers respectively.

Table 1. Chemical compositions of major (wt.%), trace (ppm) and oxide ratios of the study profile above Syenite in Pankshin area

	Rock						Laterite				Soil			
	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S21	S22	S23	S24
SiO_2	75.91	76.01	63.44	56.94	74.85	69.43	72.39	70.05	71.22	70.39	71.30	71.20	71.25	71.54
Al_2O_3	13.51	12.75	17.65	23.98	13.03	16.18	13.48	15.02	14.25	15.02	14.40	14.60	14.50	14.60
$FeO_{3(t)}$	1.07	1.18	4.30	3.80	1.37	2.34	4.10	4.87	4.49	4.87	4.99	4.89	4.94	4.99
MnO	0.01	0.01	0.06	0.04	0.01	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
MgO	0.05	0.04	0.49	1.12	0.05	0.35	0.15	0.14	0.15	0.19	0.13	0.14	0.14	0.14
CaO	0.41	0.39	2.44	3.57	0.44	1.45	0.05	0.04	0.05	0.05	0.09	0.03	0.06	0.09
Na_2O	4.17	3.99	4.02	2.95	4.16	3.86	0.11	0.60	0.36	0.11	0.06	0.07	0.07	0.07
K_2O	4.79	4.52	5.88	4.86	4.86	4.98	1.48	0.86	1.17	1.48	0.79	0.81	0.80	0.85
TiO_2	0.05	0.05	0.05	0.35	0.06	0.11	0.57	0.63	0.60	0.62	0.06	0.40	0.23	0.16
P_2O_5	0.01	0.01	0.13	0.02	0..02	0.04	0.03	0.03	0.03	0.04	0.02	0.02	0.02	0.02
LO1	0.52	0.53	0.66	0.98	0.70	0.68	6.60	7.60	7.10	7.60	7.09	7.10	7.10	7.40
Total	100.50	99.48	99.12	98.61	99.53	99.45	98.97	99.29	99.13	100.39	99.40	99.28	99.34	99.88
Trace elements (ppm)														
Ba	18	10	3436	1253	-	1179	149	112	131	112	105	213	159	212
Sr	5	5	345	468	-	205	23	21	22	21	18	26	22	25
Y	140	206	632	19	-	249	56	60	58	60	55	61	58	56
Sc	1	1	6	5	-	3	5	6	6	5	5	9	7	7
Zr	303	280	613	342	-	385	550	637	594	711	601	651	626	650
Be	6	6	2	4	-	5	2	2	2	2	2	2	2	2
V	5	5	14	19	-	11	50	56	53	56	59	65	62	60
Silica and alumina ratios (%)														
SR	5.21	5.46	2.89	2.05	5.19	3.75	4.12	3.52	4.24	5.07	3.68	3.63	3.65	3.68
AR	12.63	10.81	4.10	4.10	9.51	8.49	3.29	3.08	4.26	6.42	2.89	2.94	2.92	2.89
MgO+CaO	0.46	0.43	2.93	4.69	0.49	2.13	0.20	0.18	0.27	0.42	0.22	0.17	0.20	0.17
Na_2O+K_2O	8.96	8.51	9.90	7.81	9.02	8.80	1.59	1.46	1.59	1.59	0.85	0.88	0.87	0.87
CIA	51.83	51.58	50.79	59.52	51.55	-	89.01	88.44	88.24	-	92.96	92.24	93.01	-

Table 2. Average chemical compositions of major (wt.%), trace (ppm) and oxide ratios of the study profile over Syenite in Pankshin area

	Rock		Laterite		Soil	
	Mean	Range n=6	Mean	Range n=4	Mean	Range n=4
SiO_2	69.43	56.94-76.01	71.22	70.09-72.39	71.25	71.20-71.54
Al_2O_3	16.18	12.75-23.98	14.25	13.48-15.02	14.50	14.40-14.6
$Fe_2O_{3(t)}$	2.34	1.07-4.30	4.49	1.99-4.87	4.94	4.89-4.99
MnO	0.03	0.01-0.06	0.02	0.02-0.02	0.02	0.02-0.02
MgO	0.35	0.04-1.12	0.15	0.14-0.19	0.14	0.13-0.14
CaO	1.45	0.39-3.57	0.05	0.23-0.05	0.06	0.03-0.90
Na_2O	3.86	2.95-4.17	0.36	0.16-0.11	0.07	0.06-0.07
K_2O	4.98	4.79-5.88	1.17	0.80-1.48	0.80	0.79-0.85
TiO_2	0.11	0.05-0.35	0.60	0.57-1.45	0.23	0.06-0.4
P_2O_5	0.04	0.01-0.13	0.03	0.03-0.04	0.02	0.02-0.02
LOI	0.68	0.52-0.98	7.10	660-760	7.10	7.09-7.10
Total	99.45		99.13		99.34	
Trace elements (ppm)						
Ba	1179	561288	130	112-433	159	105-212
Sr	206	5-468	22	21-81	22	18-25
Y	249	19-632	58	39-60	58	55-56

Sc	3	1-6	6	40487	7	4-5
Zr	385	280-342	594	550-711	626	601-650
Be	5	2-6	2	2	2	2
V	11	5-19	53	56-107	62	59-60
Silica and Alumina Ratios (%)						
SR	3.75	2.04-5.46	4.24	3.52-5.07	3.65	3.63-3.68
AR	8.49	4.15-12.68	4.26	3.08-6.42	2.92	2.89-2.94
MgO+CaO	2.13	0.43-4.69	0.27	0.18-0.42	0.20	0.17-0.22
Na_2O+K_2O	8.84	7.81-9.90	1.58	1.46-1.71	0.87	0.85-0.88
CIA	53.79	50.79-59.63	88.24	88.04-89.01	92.60	92.24-96.96

Table 3. Chemical compositions of major (wt.%), trace (ppm) and oxide ratios of the study profile above Younger Granite in Pankshin area

	Rock					Laterite			Soil			
	YG 1	YG 2	YG 3	YG 4	YG 5	YG 6	YG 7	YG 8	YG 9	YG 11	YG 12	YG 13
SiO_2	72.08	73.14	74.30	71.5	72.76	29.6	45.6	37.6	58.52	48.07	38.31	48.42
Al_2O_3	14.44	13.96	14.95	14.82	14.54	21.1	23.3	22.2	13.02	20.02	28.08	20.55
$Fe_2O_{3(t)}$	2.21	2.04	0.71	0.52	1.37	32.8	11.8	22.3	15.58	15.59	15.86	15.72
\MnO	0.04	6.03	0.01	0.009	1.52	0.05	0.10	0.08	0.08	0.05	0.05	0.06
MgO	0.66	0.57	0.12	0.09	0.36	0.07	0.36	0.22	0.19	0.19	0.11	0.15
CaO	2.29	1.75	1.20	0.38	1.41	0.02	0.34	0.18	0.06	0.05	0.05	0.06
Na_2O	3.79	3.20	5.21	2.45	3.66	0.02	0.45	0.24	0.15	0.16	0.06	0.11
K_2O	2.51	3.79	2.44	8.87	4.40	0.10	2.23	1.17	1.66	0.20	0.19	0.93
TiO_2	0.31	0.28	0.03	0.021	0.16	1.73	1.16	1.45	2.265	1.65	1.06	1.66
P_2O_5	0.10	0.08	0.04	0.07	0.07	0.16	0.12	0.14	0.09	0.01	0.07	0.08
LOI	0.65	0.63	0.48	0.45	0.55	13.8	13.00	13.40	7.32	12.6	14.91	11.12
Total	99.06	99.46	99.48	99.18	99.30	99.5	98.9	99.2	99.03	98.59	98.74	98.84
Trace elements (ppm)												
Ba	85	1158	414	493	538	61	460	260	21	21	77	49
Sr	342	429	220	182	293	26	114	70	17	18	30	23
Y	11	5	22	7	11	13	65	39	7	8	32	19
Sc	81	3	4	1	22	27	14	21	36	36	9	22
Zr	81	85	35	20	55	507	1114	811	242	300	691	466
Be	4	3	3	3	3	1	5	3	1	3	3	2
V	26	26	5	5	26	405	79	242	732	600	125	429
Silica and alumina ratios (%)												
SR	4.33	4.57	4.74	4.65	4.58	0.55	1.30	0.93	1.84	2.05	0.88	1.46
AR	6.53	6.84	21.06	28.5	15.73	0.94	1.97	1.31	0.84	1.67	1.77	1.30
MgO+CaO	2.95	2.33	1.32	0.47	1.77	0.09	0.70	0.40	0.25	0.50	0.16	0.21
Na_2O+K_2O	6.30	6.99	7.65	11.32	8.07	0.12	2.68	0.16	1.81	0.22	0.25	1.03
CIA	52.87	53.12	53.21	51.30	52.60	99.18	86.27	91.96	96.02	94.45	98.63	94.30

Table 4. Average chemical compositions of major (wt.%), trace (ppm) and oxide ratios of the study profile over Younger Granite in Pankshin area

	Rock		Laterite		Soil	
	Mean	Range n=5	Mean	Range n=3	Mean	Range n=4
SiO_2	72.76	71.50-74.3	37.60	29.60-45.60	48.42	38-58
Al_2O_3	14.54	13.96-14.95	22.20	21.10-23.3	20.55	13.02-28.08
$Fe_2O_{3(t)}$	1.37	0.52-2.21	22.30	11.80-32.8	15.72	15.58-15.86
MnO	1.52	0.01-6.03	0.08	0.05-0.1	0.06	0.06-0.08
MgO	0.36	0.09-0.66	0.22	0.07-0.36	0.15	0.11-0.19
CaO	1.41	0.38-2.29	0.18	0.02-0.34	0.06	0.05-0.06
Na_2O	3.66	2.45-5.21	0.24	0.02-0.45	0.11	0.06-0.15
K_2O	4.40	2.44-8.87	1.17	0.10-2.23	0.93	0.19-1.66
TiO_2	0.16	0.02-0.03	1.45	1.16-1.73	1.66	1.06-2.27
P_2O_5	0.07	0.04.0.1	0.14	0.12-0.16	0.08	0.07-0.09
LOI	0.55	0.05-0.07	13.40	0.12-0.16	11.12	7.32-14.91
Total	99.30		99.20		98.84	
Trace elements (ppm)						
Ba	537	414-1158	260	61-460	49	21-77
Sr	293	182-429	70	26-114	23	17-30
Y	11	5-22	39	13-65	19	7-32
Sc	22	3-81	20	14-27	22	7-36
Zr	55	20-85	810	507-1114	466	242-691
Be	3	1-4	3	1-5	2	1-3
V	26	5-26	242	79-405	428	125-732
Silica and Alumina ratios (%)						
SR	4.58	4.33-4.74	0.93	0.55-1.30	1.46	0.87-2.05
AR	15.73	6.53-28.50	1.31	9.64-1.77	1.30	0.84-1.77
MgO+CaO	1.77	0.47-2.95	0.40	0.70-0.90	0.21	0.16-0.25
Na_2O+K_2O	8.07	6.30-11.32	0.16	0.12-2.68	1.03	0.25-1.81
CIA	52.60	51.30-53.12	97.32	96.02-98.63	91.20	98.18-98.35

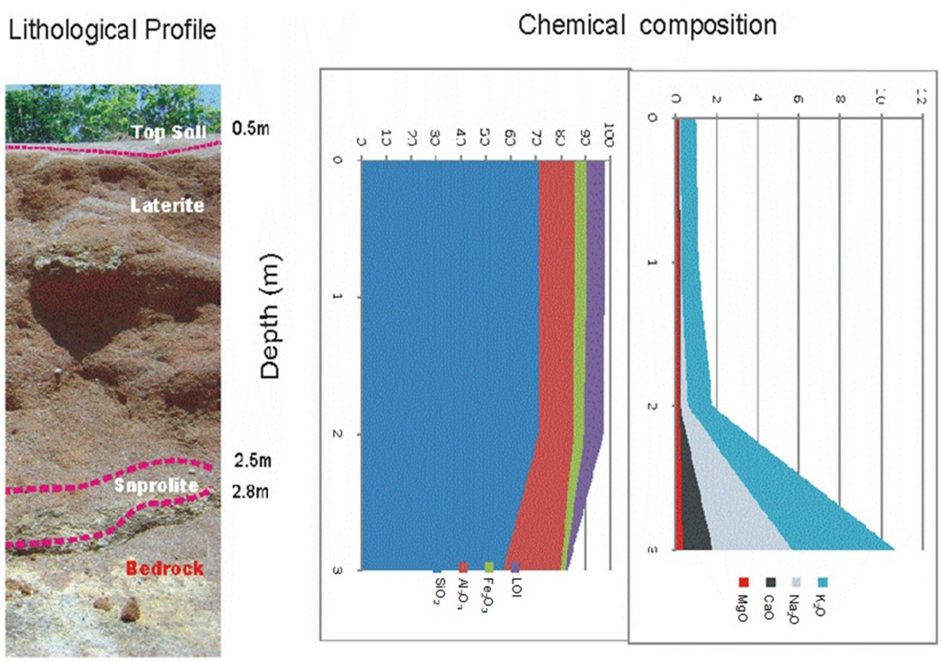


Figure 9. Chemical variation along vertical profile over study Syenite in Pankshin area

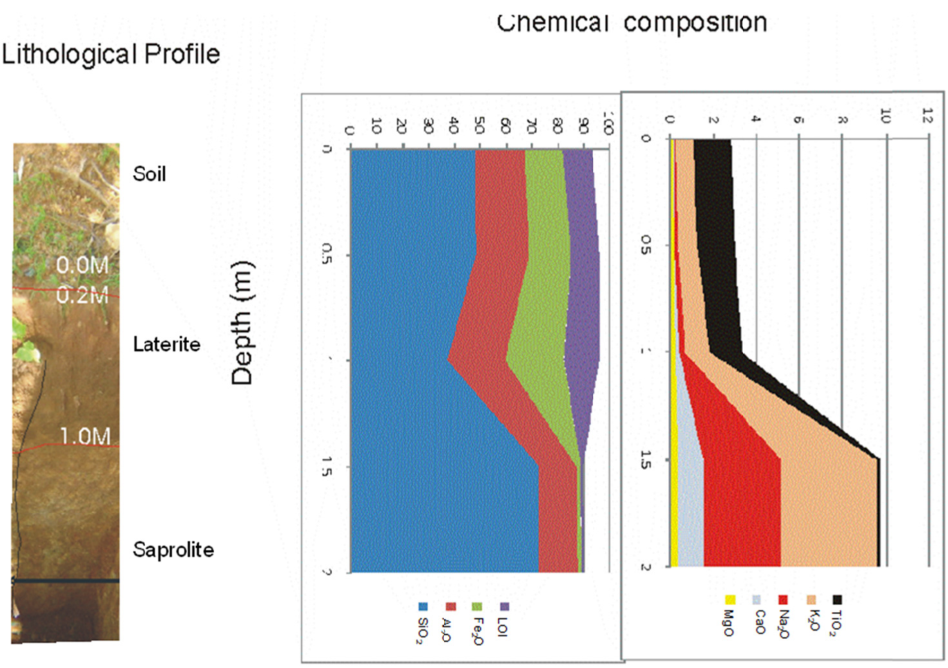


Figure 10. Chemical variation along the vertical profile over study Younger Granite in Pankshin area

4.5 Accumulation Factor (AF), Loss and Gains of Elements (K) in the Study Profiles

Accumulation factor (AF) and loss and gains of elements (K) in the Syenite profile (Table 5) show that SiO_2, Fe_2O_3 and TiO_2 have AF values greater than 1 in the laterite and the soil characterised by loss of Al_2O_3, MnO_2, MgO, CaO, Na_2O, K_2O and P_2O_5. Only Fe_2O_3, TiO_2, V, Sc and Zr were accumulated in the laterite profiles overlying the Syenite (Figure 11).

The AF and K values of the profile over Younger Granite (Table 6) show that Al_2O_3, Fe_2O_3, P_2O_5, and TiO_2 are enriched in the laterite and soil whereas other major oxides SiO_2, MnO, MgO, CaO, and Na_2O are depleted relative to the parent rock. Trace elements notably Y, Zr and V have AF values greater 1, indicating enrichment, while Ba, Sr, Sc, Be are depleted (Figure 12). The K values support the general observation that during chemical weathering of virtually all types of rock, loss of elements rather than gain are more prevalent because most of the elements are leached during weathering (Kehinde Phillips 1991). A critical assessment of the AF and K of the Younger Granite profile show that Fe_2O_3 and TiO_2 are enriched in the laterite and soil indicating probable iron and titanium ore enrichment.

5. Conclusions

Weathered profile overlying Syenite and Younger Granite in Pankshin area show three distinct horizons; top-soil, laterite and saprolite/bedrock based on their colour, textures and structures. The mineralogy along the profile over Younger Granite show incipient weathering while the CIA values show advanced stage of weathering in both the Syenite and the Younger Granite. The soil formed from Younger Granite is lateritic, whereas that of Syenite is non-lateritic. The Younger Granite profile show higher intensity of weathering compared to that of the Syenite. The trend of weathering in both profiles is towards iron enrichment and not aluminium enhancement. The profile over Younger Granite show possible iron and titanium ore mineralization.

Table 5. Accumulation Factor (AF), Loss and Gain (K) of elements of the study Syenite profile in Pankshin area

	Rock	Laterite			Soil		
	Mean	Mean	AF	K	Mean	AF	K
SiO_2	69.43	71.22	1.03	0.1	71.25	1.03	1.3
Al_2O_3	16.18	14.25	0.88	-0.2	14.5	0.90	-5.0
$Fe_2O_{3(t)}$	2.34	4.49	1.92	1.8	4.94	2.11	53.3
MnO	0.03	0.02	0.67	-0.7	0.02	0.67	-16.0
MgO	0.35	0.15	0.43	-1.1	0.14	0.40	-28.8
CaO	1.45	0.05	0.03	-1.9	0.06	0.04	-46.0
Na_2O	3.86	0.36	0.09	-1.8	0.07	0.02	-47.1
K_2O	4.98	1.17	0.23	-1.5	0.8	0.16	-40.3
TiO_2	0.11	0.6	5.45	8.9	0.23	2.09	52.4
P_2O_5	0.04	0.03	0.75	-0.5	0.02	0.50	-24.0
Ba	1179	130	0.11	-78.3	159	0.13	-41.5
Sr	206	22	0.11	-78.6	22	0.11	-42.9
Y	249	58	0.23	-67.5	58	0.23	-36.8
Sc	3.25	5.5	1.69	60.9	7	2.15	55.4
Zr	385	594	1.54	47.8	626	1.63	30.1
Be	5	2	0.44	-48.9	2	0.44	-26.7
V	11	53	4.93	345.9	62	5.77	228.8

- represent loss + represent gain

Table 6. Accumulation Factor (AF), Loss and Gain (K) of elements in the study Younger Granite profile in Pankshin area

	Rock	Laterite			Soil		
	Mean	Mean	AF	K	Mean	AF	K
SiO_2	72.76	37.60	0.52	-5.30	48.42	0.67	-3.30
Al_2O_3	14.54	22.20	1.53	5.80	20.55	1.41	4.10
$FeO_{3(t)}$	1.37	22.30	16.28	168.10	15.72	11.47	104.70
MnO	1.52	0.08	0.05	-10.40	0.06	0.04	-9.60
MgO	0.36	0.22	0.61	-4.30	0.15	0.42	-5.80
CaO	1.41	0.18	0.13	-9.60	0.06	0.04	-9.60
Na_2O	3.66	0.24	0.07	-10.30	0.11	0.03	-9.70
K_2O	4.40	1.17	0.27	-8.10	0.93	0.21	-7.90
TiO_2	0.16	1.45	9.06	88.70	1.66	10.38	93.8
P_2O_5	0.07	0.14	2.00	11.00	0.08	1.14	1.40
Ba	537	260	0.48	-5.70	49	0.09	-9.10
Sr	293	70	0.24	-8.40	24	0.08	-9.20
Y	11	39	3.47	27.10	20	1.73	7.30
Sc	22	20	0.92	-0.90	23	1.01	0.10
Zr	55	810	14.67	150.40	467	8.44	74.40
Be	3	3	0.90	-1.10	2	0.60	-4.00
V	26	242	9.31	91.40	429	16.48	154.80

- represent loss + represent gain

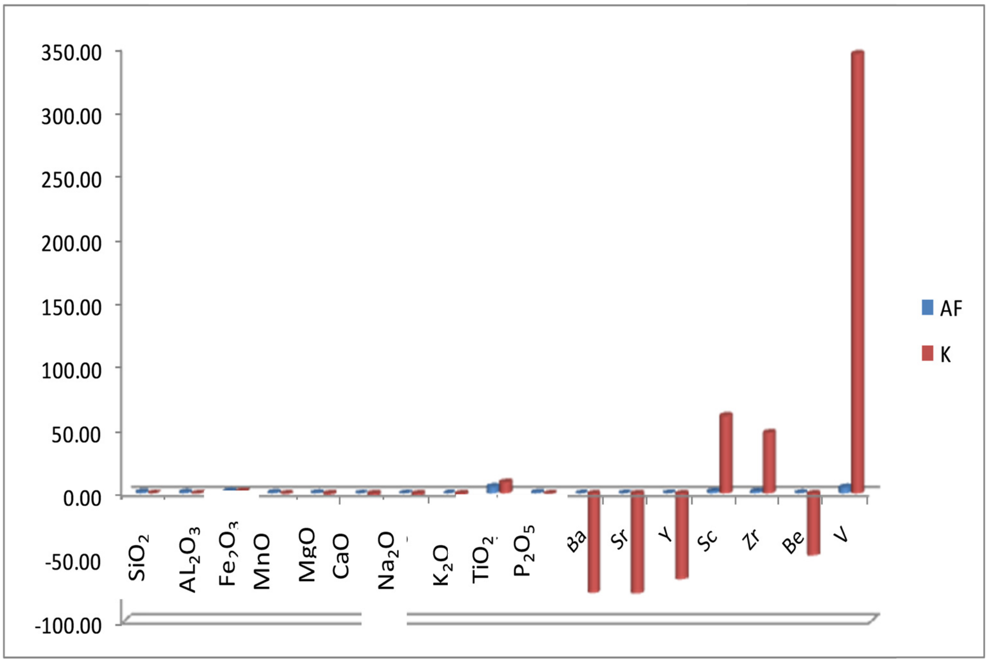


Figure 11. Histogram of AF and K in weathered profile of the study Syenite in Pankshin area.

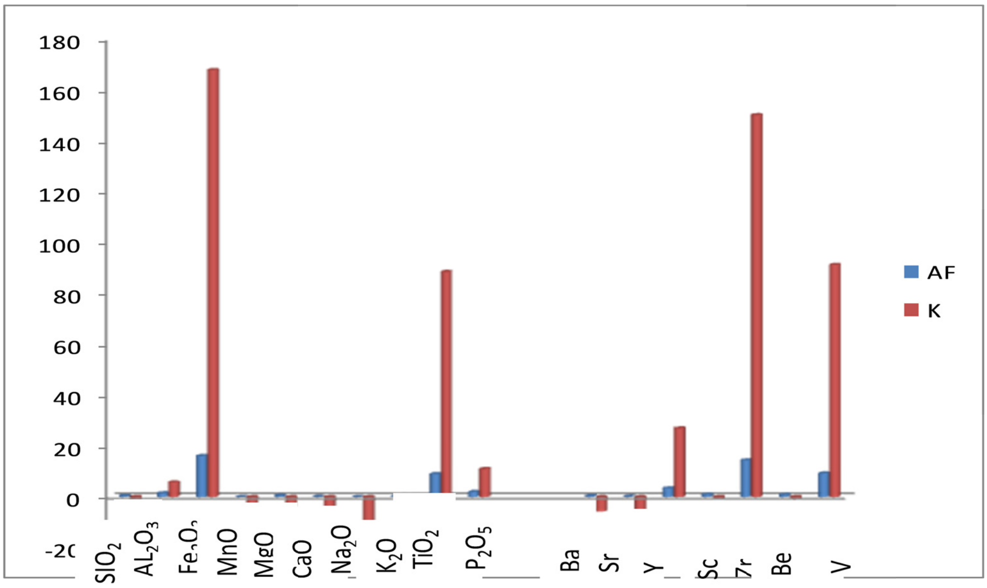


Figure 12. Histogram of AF and K in the weathered profile of the study Younger Granite in Pankshin area

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