



GEOCHEMISTRY EVOLUTION OF SCHISTS OF NORTHWEST OBUDU AREA SOUTHEASTERN NIGERIA

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ABSTRACT

Geochemistry of schists of Obudu area was carried out using ICP-MS and ICP-ES techniques in order to determine the geochemical evolution of the area. 40 samples were analyzed for their major, trace and REE composition. Field mapping revealed that gneisses, amphibolites and schists comprising migmatitic schists (MS), quartz-mica schists (QMS), garnet-mica schists (GMS), and hornblende biotite schists (HBS), intruded by granites, granodiorites, quartzo-feldspathic rocks and dolerites occur in the area. Structural studies revealed that the schists trend approximately NE–SW (5 – 30°) indicating the Pan-African event. Modal analysis revealed that the schists have average concentration of quartz (15vol.%), plagioclase (An₄₅-19 vol.%), biotite (15vol.%), garnet (9.0vol.%) and muscovite (6vol.%), the remaining consists of accessory minerals. Geochemistry showed that all the schists have molecular Al₂O₃ > CaO+K₂O+Na₂O, indicating they are peraluminous metasedimentary pelites. Trace and REE element results show that all the analyzed schist samples are depleted in Hg, Ag, Be, Bi, and Sb below < 1.0ppm, but relatively enriched in Ba, Sr and Zr with average concentration of 996, 675.73, 243.13 ppm respective. The HREE are depleted with ΣHREE < 10.2, but the LREE are relatively enriched with ΣLREE > 289.54. The ΣLREE/ΣHREE ratio ranges from 9.17 to 33.4, with a large positive delta V at Eu. These findings indicate that the schists of Northwest Obudu area are highly fractionated and had attained at least the uppermost amphibolite metamorphic grade. The schists had contributed to the development of the Pan-African continent.

KEYWORDS: Evolution, Petrology, Geochemistry, Obudu area, Trace and REE Elements.

1.0 INTRODUCTION

Northwest Obudu is a part of the Obudu, Oban, Bamenda massif which extends from western Cameroun into Southeastern Nigeria in the West African sub-region (Toteu et al., 1987). The area is particularly delineated within Latitudes 5°45'N – 6°00'N and longitudes 7°00'E – 7°09'E (Fig.1). The schists of Northwest Obudu area occur in association with other basement rocks, including migmatitic gneiss, granite gneiss, amphibolites, meta-quartzites and other rocks Obioha (2014); Obioha and Ekwueme (2012). The basement rocks had been intruded by various igneous rocks including granites, granodiorites, aplites, dolerites and quartzo-feldspathic rocks. Several scholars including Ekwueme (1985), Ejimofor (1988), Ejimofor et al., (1996), Shaw (1994), and many others have worked in Obudu area. Recent works in the area include those of Ekwueme (2010), Obioha and Ekwueme (2011, 2012), Obioha et al., (2013). However, more work needs to be done for a better classification of the geochemistry of the schists of Obudu area. This study uses the major, trace and rare earth element of the schists to unravel the geochemical evolution of the area.

1.2 Location of Study Area

The area of study, Northwest Obudu-Bamenda Massif, is geographically situated between Latitudes 6°45'N - 7°00'N and Longitudes 9°00'E - 9°16'E (Fig. 1). It covers a surface area of about 860.32 km² (Obioha, 2014) extending from Ushongo - Kwande and Vandeikya Local Government Areas in southern Benue State, to parts of Obudu and Bekwara Local Government Areas in northern Cross River State of Southeastern Nigeria (Obioha, 2014). The area is bounded in the west and northwest by Benue Trough, in the south by Mamfe Embayment, which separates it from the Oban Massif in Cross River State, and on the east by the Bamenda Massif of western Cameroon from which it extends into Southeastern Nigeria (Toteu et al., 1987). The major access roads to the area are the Calabar – Ikom – Ushongo high ways and the Obudu – Vandeikya – Gboko roads. The area experiences two seasons: dry which lasts from October to March, and rainy which lasts from March to October each year. The temperature ranges from about 27°C – 33°C, with average annual rainfall range of 1200 – 2000mm, and moderate to high relative humidity of ~ 80 - 90% (CRBDA, 1986). The

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vegetation is the rain forest type which is gradually giving way to the Savanna grass land type in places due to intense agricultural activities in the area.

2.0 GEOLOGICAL SETTING

Northwest Obudu area is a part of the Pan-African Basement terrains in southeastern Nigeria (Obiora and Charan, 2010; Oden, et al, (2011). The area is underlain by about 70% basement rocks and 30% sedimentary rocks (Reyment, 1967; Figs, 1 & 2). The Hawal massif in the NE is separated from the Adamawa-Obudu Plateau by the Benue valley, while the Ikom depression separates the Obudu-Bamenda Plateau from the Oban Massif in Cross River State (Rahman et al, 1981). The area has suffered magmatic intrusion, metamorphism, tectonic deformation, geochemical and geodynamic evolution and sedimentation resulting in the occurrence of migmatites, gneisses, schists, amphibolites, meta-quartzites and metagabbros, intruded by granites, granodiorites, tonalites, gabbros, and aplites (Ekwueme, 1994, 2010; Obiora and Charan, 2010; Obioha and Ekwueme, 2011, 2013; Obioha et al. 2013). The Nigerian sedimentary environment is characterized by the occurrence of seven major basins including the Niger Delta, Benue Trough, Sokoto/Illumedun, Bornu, Calabar, Anambra and Afikpo basins, and other numerous minor sub-basins (Benkhelil, 1986).

3.0 MATERIALS AND METHOD

The study involved geological field mapping and sampling and laboratory analysis. The field mapping was carried out between January and March when the environment was dry and the outcrops were well exposed. 40 representative rock samples were collected, processed and analyzed.

3.1 Sample Preparation and Analytical Method

The samples for whole rock geochemical analysis were prepared by the conventional dressing techniques. The analytical packages are the G4A-G4B techniques, carried out at the ACEME Analytical Laboratory, Vancouver Canada. Two separate analytical methods; inductively coupled plasma mass spectrometry (ICP-MS) and inductively coupled plasma emission spectrometry (ICP-ES) were employed. The cutting, grinding, pulverization and weighing were done by

special electronic handling (SEH). The digestion was by Li-Borate and Li-tetra-borate and HCl. The resolution was 0.001ppm for the trace and rare earth elements and 100% for the major elements quoted as their oxides wt. %.

4.0 RESULT AND DISCUSSION

The sample location map is shown in Fig. 1, while Fig. 2 shows the geological map of the area (Obioha, 2014). The modal composition of the schists of Northwest Obudu area are presented in Table 1. The table shows average result for ten (10) runs for each of the samples of the schists mapped; the migmatitic (MS), biotite mica (BMS), quartz mica (QMS) and hornblende biotite schist (HBS) (Obioha et al., 2013). The modal compositions of the schists are summarized in Table 1. Fig. 3 shows the research flow sequence. Figs. 4 a-c, show the field relationship of the various schists mapped in the area.

4.1 Quartz Mica Schist

The quartz mica schist (QMS, Table 1, and Fig. 4) occurs around Mbakeum and Vandeikya areas in Northwest Obudu-Bamenda area. This schist outcrop is fine to medium grained, and shows greenish streak colorations due to the presence of ferromagnesian minerals (mainly biotite, garnet and hornblende). The foliation trends NE –SW (0 – 30°) directions with dips (~ 0 – 10°) mainly in the NW indicating the Pan-African trend.

4.2 Migmatitic Schist

This Schist (Table 1, Fig. 4) crops out around Bara-Azov hill and Dura River channel in the study (Fig. 1) area shows well-defined porphyroblastic texture with megacryst garnet set in smaller ground mass of biotite and muscovite flakes (Obioha, 2014). The schist is shattered, complexly deformed indicating pre-tectonic/syn-tectonic deformation. The modal analysis of the MS is shown in (Table 1). The table shows that the mineral paragenesis of the migmatitic schist averages biotite (10 vol. %), muscovite (7 vol. %), garnet (18 vol. %), orthoclase (10 vol. %), plagioclase (24 vol. %) and quartz (20 vol. %). Epidote, kyanite, sillimanite, chlorite and magnetite occur in accessory amounts. The co-existence of sillimanite and chlorite indicates that the area had suffered retrograde metamorphism.

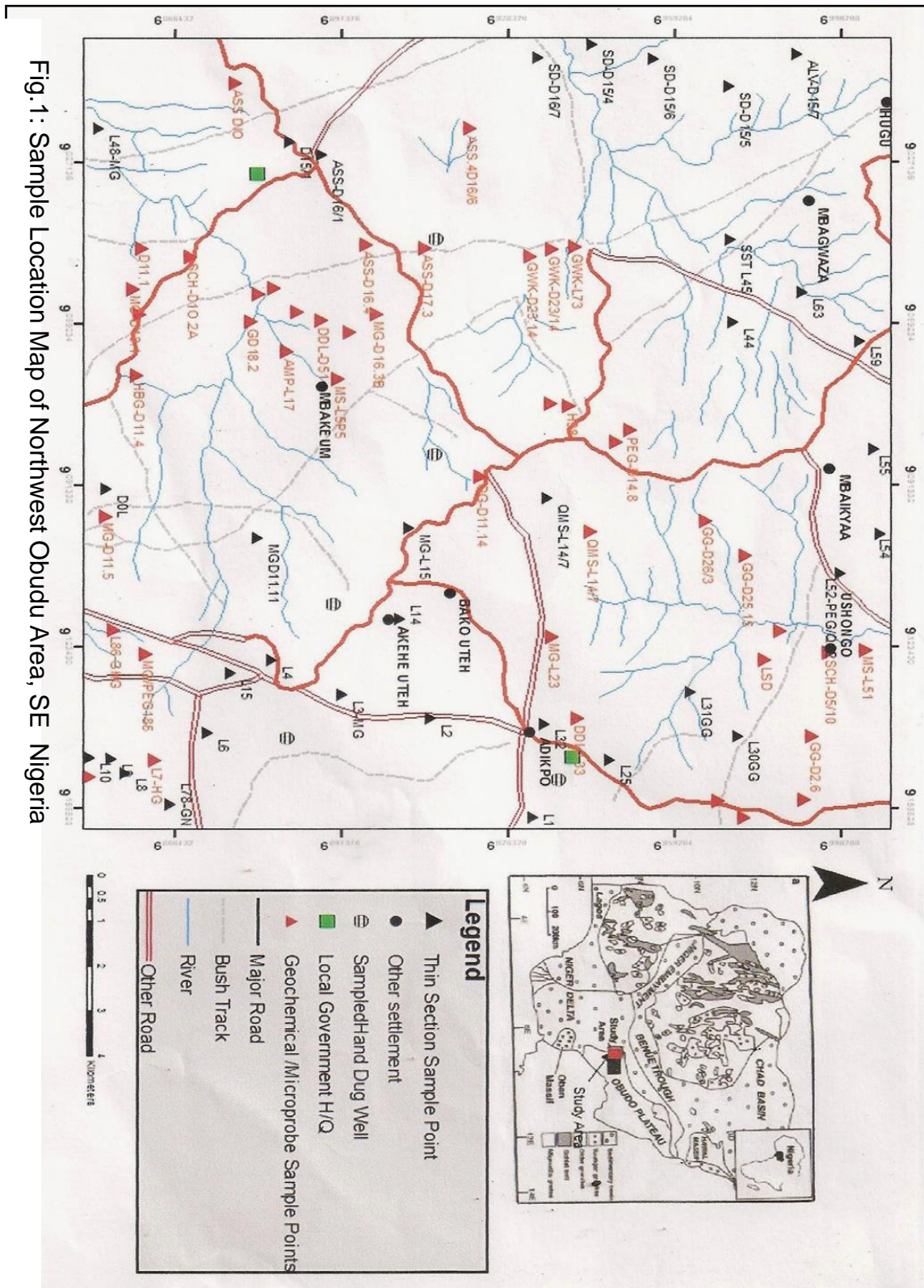


Fig. 1: Sample Location Map of Northwest Obudu Area, SE Nigeria

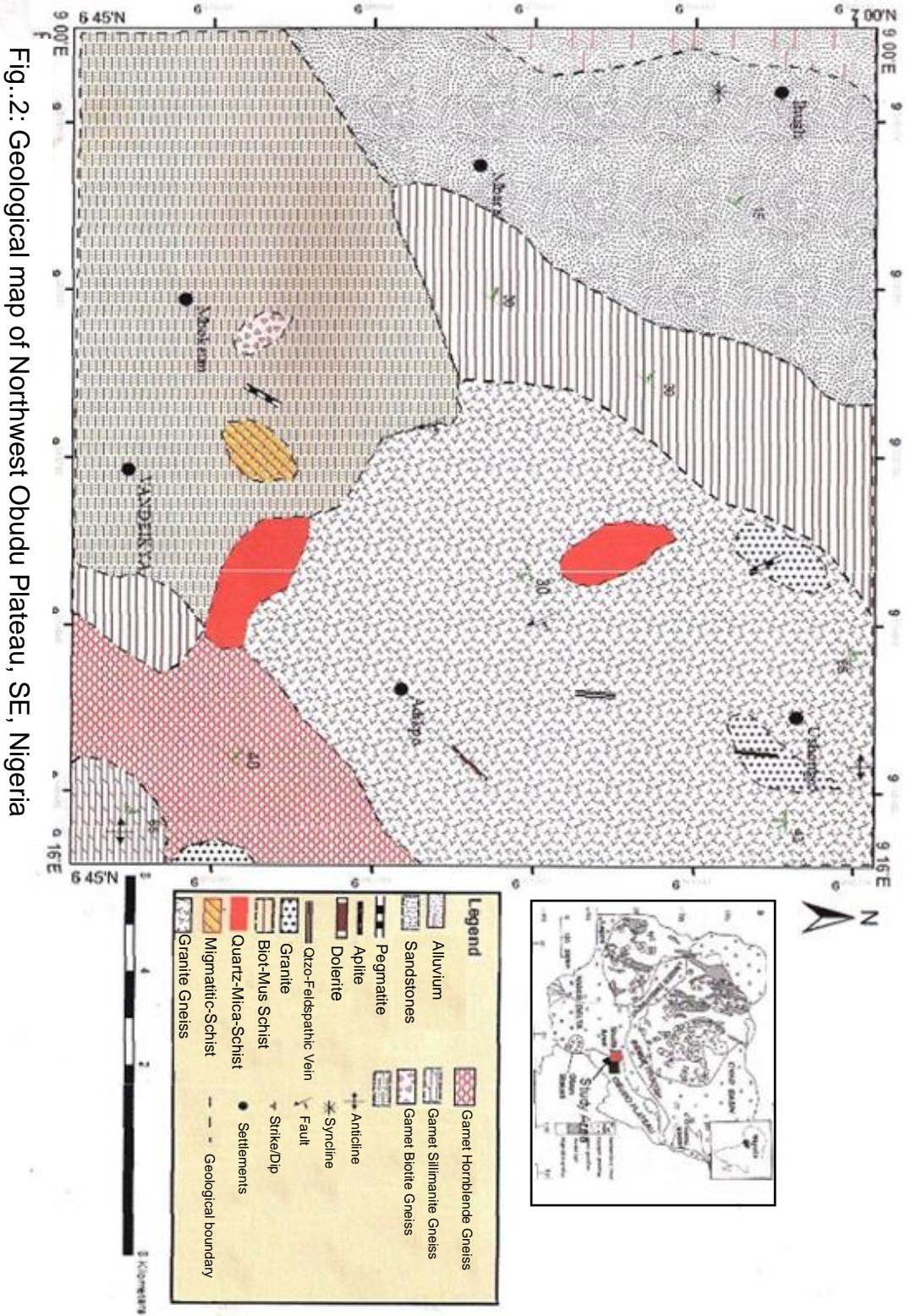


Fig. 2: Geological map of Northwest Obudu Plateau, SE, Nigeria

Table 1: Average modal composition (vol. %) of Schists of NW Obudu, SE. Nigeria (Obioha et al., 2013)

Minerals	MS, n = 10	QMS, n = 10	BMS, n = 10	HBS, n = 10	Mean = $\sum A-D/N$
Quartz	27	30	23	5	19.50
Plagioclase	21	20	20	18	19.75
Orthoclase	3	16	15		12.75
Biotite	13	8	25	20	15.75
Muscovite		15	6	-	6.75
Garnet	18	5	5	8	9.00
Epidote	1	1	1	-	0.75
Kyanite	1	2	2	-	1.25
Sillimanite	3	1	1	-	1.25
Hypersthene	3	-	-	-	0.75
Chlorite	-	-	-	2	0.50
Hornblende	-	-	2	40	10.5
Corundum			-	-	1.25
Total	100	100	100	100	100

Mineralogical Assemblage: Qtz + Plag + Orth + Gar + Biot + Mus \pm Sill \pm Epdt; in the migmatitic schist (MS)
 Qtz + Plag + Orth + Gar + Musc + Biot \pm Sill \pm Epdt; in the quartz mica schist (QMS) and biotite mica schist (BMS); Hnb + Gar + Biot + Qtz \pm Chlt, in the quartz mica

schist (QMS). Nb; N = number of analyses per lithological type.

KEY: MS = Migmatitic Schist from Dura River. QMS = Quartz Mica Schist. BMS = Biotite Muscovite Schist. HBS = Hornblende Biotite Schist.

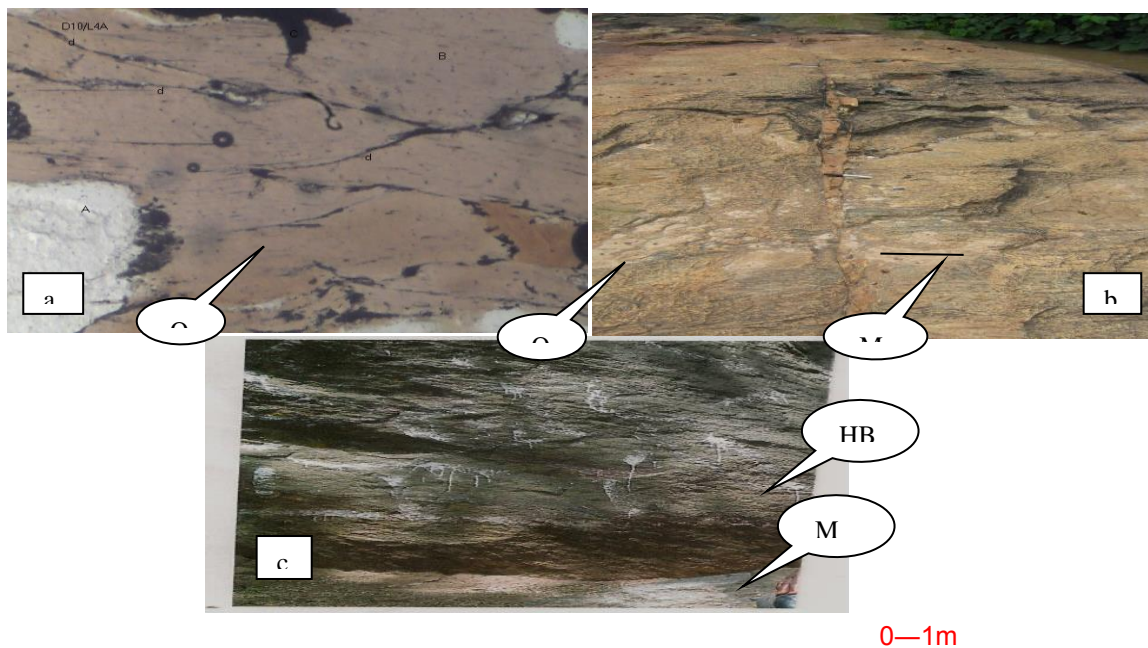


Fig. 4: a). Migmatitic schist (MS), showing NW-SE ($\sim 0 - 15^\circ$) trending foliation defined by platy minerals (biotite, muscovite, hornblende). b). Quartz-mica-schist (QMS), showing quartz (Q), muscovite (M) with inclusions of biotite (B) and garnet (G). c). Hornblende biotite schist (HBS), showing NW – SE trending foliation, and in sharp contact with the underlying migmatitic gneiss (MG), Northwest Obudu Plateau Bamenda Massif SE., Nigeria. The rock has been variously intruded by pegmatitic and quartzo-feldspathic veins (Fig. 4), which often truncate the original rock foliation. The modal analysis is shown in Table 4.

4.3 Biotite Muscovite Schist

The biotite muscovite or 2-mica schist (Table 1; Fig. 4), crops out in the Dura and Aya rivers channels around Lessel and Vandeikya areas of the study area (Obioha, 2014). The schistosity trends mainly in the NE-SW direction, which indicates that it may be a product of pre Pan – African deformation episode (Ekwueme, 2010). It

occurs as relic enclaves or boulders in the migmatitic / granite gneisses. Unlike the migmatitic schist which shows gradational to diffused contact, the biotite muscovite schist exhibits sharp contact with the host migmatitic gneiss. The result of the modal analysis of the biotite muscovite schist (Table 1) shows that it is composed of biotite (25 %), quartz (23 %), plagioclase (20 %), orthoclase (15 %), muscovite (6 %), garnet (5 %) and hornblende (2 %) (Table 1).

4.4 Hornblende Biotite Schist

The hornblende biotite schist (HBS; Table 1; Fig. 4) is restricted in occurrence. It is found mainly as enclave, closely associated with the migmatitic gneiss in the study area. It shows foliation trending approximately NW – SE ($0-10^\circ$) indicating the Pan African trend. The result of the modal analysis of the schist is shown in (Table 1). The table shows that the HBS is composed dominantly of hornblende (40 vol. %), biotite (20 vol. %), plagioclase (15 vol. %), garnet (10 vol. %) and quartz (5 vol. %),

while opaques and accessory minerals constitute the rest of the modal volume (Table 1).

4.5 Major Element Geochemistry

The whole rock major element geochemistry of the schists of Northwest Obudu together with their CIPW and Niggli Norms are shown in (Table 2). The average SiO₂ concentration of the schists varies from 63.59 wt % in the HBS through 65.97 wt % in the GMS and 68.36 wt % in the QMS. Hence the GMS, MS and QMS classify as metapelites derived from meta-sedimentary protoliths. The Fe₂O₃ content of the schists was fairly constant, ranging from 2.98 - 5.91 wt %, with average value of 4.57 wt %, (Table 2).

4.6 Trace Element Composition

Results of the trace elements abundance and distribution in the schists of Northwest Obudu-Bamenda area are presented in Table 3. The table shows that the trace elements are highly differentiated across all the analyzed samples. The critical trace element Ba varies from 370 ppm in the hornblende biotite schist (HBS) through 1803 ppm in the quartz mica schist (QMS) at Mbakeum to maximum enrichment of 1814 ppm in the garnet mica schist (GMS), with average concentration of 995.67 ppm which is ~ x2 to x5 the average crustal abundance of Ba-400ppm (Taylor, 1965; Taylor and McLennan, 1985). Similarly, Rb varies from 53.6 ppm in HBS, through 117.8 ppm in the GMS to 121.7 ppm in the QMS. The Sr shows an enrichment trend from 504.5 ppm in the HBS through 751.6 in the QMS to 771.1 ppm in the GMS (Table 2) (Obioha and Ekwueme, 2013).

Table 2: Whole Rock Major Elements Geochemistry (wt. %) of Schists of NW Obudu Area, S. E. Nigeria.

Oxide	MS	MS	GMS	BMS	QMS	QMS	HBS	ΣN/n
SiO ₂	64.34	60.11	65.97	62.94	66.58	68.36	63.59	64.56
Al ₂ O ₃	15.87	16.46	15.42	17.13	14.99	16.36	15.31	15.53
TiO ₂	0.42	0.96	0.74	0.67	0.68	0.47	0.45	0.63
Fe ₂ O ₃	4.26	5.91	4.39	5.40	4.14	2.98	4.90	4.57
MgO	3.05	3.34	2.49	2.26	2.31	1.09	3.23	2.54
CaO	4.91	3.20	2.66	2.11	2.56	3.16	5.10	3.39
MnO	0.07	0.06	0.05	0.06	0.04	0.03	0.08	0.056
Na ₂ O	4.42	3.48	3.45	3.46	3.42	4.40	4.29	3.85
K ₂ O	1.54	3.88	3.50	3.66	3.45	1.92	1.52	2.78
P ₂ O ₅	0.20	0.61	0.25	0.13	0.22	0.08	0.20	0.24
Cr ₂ O ₅	0.012	0.012	0.009	0.01	0.008	0.002	0.015	0.0097
LOI	0.70	1.40	0.70	1.7	1.2	1.0	1.10	1.114
Total	99.91	99.91	99.63	99.95	99.60	99.98	99.79	99.27
CIPW Norm of Schists of NW Obudu, SE Nigeria								
Q(S)	19.4	14.28	18.9	18.3	20.6	25.1	16.2	22.5
Or	9.0	27.8	20.57	22.3	20.6	11.6	9.0	16.8
Ab	37.0	29.4	29.35	29.4	29	37.2	36.2	32.7
An	19.18	13.6	13.07	11.0	12.5	15.0	18.1	8.4
C(A)	-	1.8	1.12	3.8	1.0	1.5	-	-
Di	9.11	4.2	-	6.0	-	6.1	8.5	6.1
Hy	-	4.2	13.2	5.0	12.2	-	7.9	3.2
Ol	-	-	-	-	-	-	-	-
Mt	-	-	-	-	-	3.0	-	-
He	3.5	-	-	-	-	-	-	3.73
Il	0.76	2.0	1.45	1.22	1.4	1.0	1.0	1.1
Ap	1.86	2.5	1.86	1.0	1.9	0.6	2.0	2.0
Niggli Norm of Schists of NW Obudu, SE Nigeria								
Al	41.05	42.76	37	47.98	38	50.4	32	44.19
Fm	20.84	25.07	29	22.28	27	12.97	31	21.12
C	18.96	11.85	11	8.421	12	13.87	19	13.74
Alk	19.15	20.33	23	21.323	23	22.68	18	20.99
Si	231.88	207.67	263	234.46	280	280.06	223	244.31
Ti	0.89	1.96	2.19	1.472	2.302	1.14	1.28	1.41
P	0.31	0.89	0.49	0.205	0.512	0.14	0.43	0.39
K	0.19	0.42	0.40	0.408	0.402	0.22	0.19	0.32
Mg	0.44	0.38	0.53	0.458	0.495	0.29	0.56	0.38
Qz	+155	+126	+71	+15	+88	+189	+51	+160
al+c	60.02	54.6	48	56	50	64.27	51	57.93
al-c	22.1	30.92	26	40	26	36.53	13	30.45

Key: L5P5-QMS = Quartz mica schist. D14.2A-GMS = Garnet mica schist. D10.2A-HBS = Hornblende biotite

schist. Fe as Fe₂O₃ total. Sample description remains as stated under Table 1. Q(s) = quartz, Or = orthoclase, Ab

= albite, An = anorthite, C(A) = corundum, Di = diopside, Hy = hypersthene, Ol = olivine, Mt = magnetite, He = hematite, Il = ilmenite, Ap = apatite.

The Sr value ranges from 504.5 in HBS, through 751.6 ppm in the QMS to 771.1 ppm in the GMS (Table 2). The Tl content ranges from 0.3 to 0.5 ppm indicating derivation from shale or crustal greywacke parent sources (Taylor, 1965; Ekwueme, 1993). Ga varies narrowly from 19.4 ppm to 19.6 ppm in all the analyzed schists sample, Sn varies from 1 – 2 ppm. The Zn concentration ranges from 52 ppm in the HBS to maximum value of 81 ppm in the QMS (Table 2). The Se, As, Cd, Sb, Bi, and Ag were depleted in all the analyzed samples < 1.0 ppm, while Hg was < 0.01 ppm (Table 2). These geochemical trends indicate a derivation from crustal materials of pelitic origin, such as shale, clays and mudstones (Taylor, 1965; Ekwueme, 1993; Ukaegbu and Ekwueme, 2005). The chalcophile elements Cd, Sb, as well as Bi and the precious metals Ag and Hg are depleted in all the analyzed schist samples with values < 0.1 ppm, indicating derivation from a common primitive protolith.

4.7 REE Composition

Results of the rare earth element (REE) geochemistry of schists of Northwest Obudu area are presented in (Table 3). The table shows that the QMS and GMS samples are almost homogenous in composition. There is a general enrichment of the LREE: La (16.7-73.3 ppm), Ce (39.9 – 136.6 ppm), Pr (5.39 – 15.24 ppm), Nb (24.4 – 55.6 ppm), Sm (4.37 – 7.48 ppm), and marked -ve anomaly at europium (Eu - 1.16 - 1.32 ppm mean range), and average value of 1.14 ppm. The HREE is

highly depleted, with Σ HREE range of 8.2 – 10.03 ppm (Table 3; Obioha, 2014). The table shows that the highest REE depletion occurs in the HBS (Σ HREE = 8.03), while the QMS shows the highest enrichment value of Σ LREE (289.54 ppm). Lu shows the least depletion of 0.1 in the (QMS and GMS), with average concentration of 0.13 ppm (Table 3). Correlation shows that the REE results of the Obudu-Bamenda area are in conformity with the petrography, major elements and trace elements analytical results (Tables 1, 2 and 3).

4.8 Petrogenesis

The REE versus Chondrite normalized spidergrams plots of schists of Northwest Obudu area shows the individual plot of the schists (Fig. 8). All the schists show enrichment from La through Sm, a +ve delta V at Eu, a marked constriction at Ga and Tb, followed by a general depletion from Dy to Lu (Fig. 8). The areal plot of the REE versus Chondrite normalized spidergrams plot (Fig. 9) shows a homogenous REE composition. This strongly shows that all the schist samples were derived from similar and / or same parental protolith.

In the ACNK versus ANK binary diagram (Fig. 10) for discrimination of rocks of Northwest Obudu area > 80% of the schists fell in the peraluminous field, while ~20 fell in the metaluminous field, showing that the schists of NW. Obudu area are predominantly peraluminous. This corroborates both the petrography and the major element results. In the SiO₂ versus Na₂O+K₂O binary discriminant for rocks of Northwest Obudu area (Fig. 11), > 90% of the analyzed schists of NW. Obudu area fell in the sub-alkaline field. These show that the major, the trace and the REE results are in conformity with the petrogenetic analysis.

Table 3: Average Trace Element abundance (ppm) in schists of NW. Obudu area, SE. Nigeria.

T.E	HBS	QMS	GMS	Σ /N.SH
Ba	370	1803	1814	995.67
Rb	53.6	121.7	117.8	94.36
Sr	504.5	751.6	771.1	675.73
Zr	131.3	315.8	282.3	243.13
Ni	57	42	42	47
Pb	1.5	3.7	4.3	3.1667
Cu	3.4	3.5	4.1	3.667
Zn	52	81	78	70.33
Co	15.4	11.9	11.0	12.767
Be	<1	<1	<1	<1
Cs	0.6	1.3	1.2	1.033
Ga	16.7	19.4	19.6	18.567
Hf	3.5	8	6.8	6.1
Sc	11	6	5	7.333
Nb	5.0	9.9	9.6	8.167
Sn	2	2	1	1.667
Ta	0.3	0.6	0.7	0.533
Th	1.0	25.6	25.5	17.367
U	0.2	1.8	2.1	1.3667
Cr	102.67	61.61	54.76	73.01
V	74	59	60	64.333
W	0.5	0.5	0.5	0.5
Y	13.4	10.3	9.2	10.967
Tl	0.3	0.6	0.5	0.4667
Mo	1.1	0.7	1.1	0.9667
Se	<0.5	0.7	<0.5	0.5667
As	0.5	0.5	0.8	0.6
Cd	<0.1	<0.1	<0.1	<0.1
Sb	<0.1	<0.1	<0.1	<0.1
Bi	<0.1	<0.1	<0.1	<0.1
Ag	<0.1	<0.1	<0.1	<0.1
Au	<0.5	<0.5	<0.5	<0.5
Hg	<0.01	<0.01	<0.01	<0.01

Table 4: Rare earth element (REE) distribution and abundance (ppm) in analysed schists of NW. Obudu area, Southeastern Nigeria.

REE	HBS	QMS	GMS	$\Sigma/N.SH$
La	16.7	73.3	69.7	53.23
Ce	39.9	136.6	124.4	110.3
Pr	5.39	15.24	14.26	11.63
Nd	24.4	55.6	50.6	43.53
Sm	4.37	7.48	6.89	6.25
Eu	1.16	1.32	1.33	1.14
Gd	3.56	3.82	3.89	3.76
Tb	0.49	0.48	0.47	0.48
Dy	2.57	2.08	1.96	2.20
Ho	0.46	0.37	0.33	0.387
Er	1.31	0.84	0.76	0.97
Tm	0.2	0.13	0.12	0.13
Yb	1.26	0.85	0.65	0.92
Lu	0.18	0.10	0.10	0.13
ΣREE	101.95	298.21	275.46	235.057
$\Sigma LREE$	91.92	289.54	267.18	226.08
$\Sigma HREE$	10.03	8.67	8.28	8.977
$\Sigma LREE/\Sigma HREE$	9.165	33.396	32.268	25.184

ΣREE = Total rare earth elements abundance (sum La + Ce + ... + Lu). $\Sigma LREE$ = Total lighter rare earth elements abundance (sum La + Ce + ... + Eu). $\Sigma HREE$ = Total heavy rare earth elements abundance (sum Lu + Yb + ... + Gd). $\Sigma LREE/\Sigma HREE$ = Ratio of Total lighter rare earth elements to Total heavy rare earth elements.

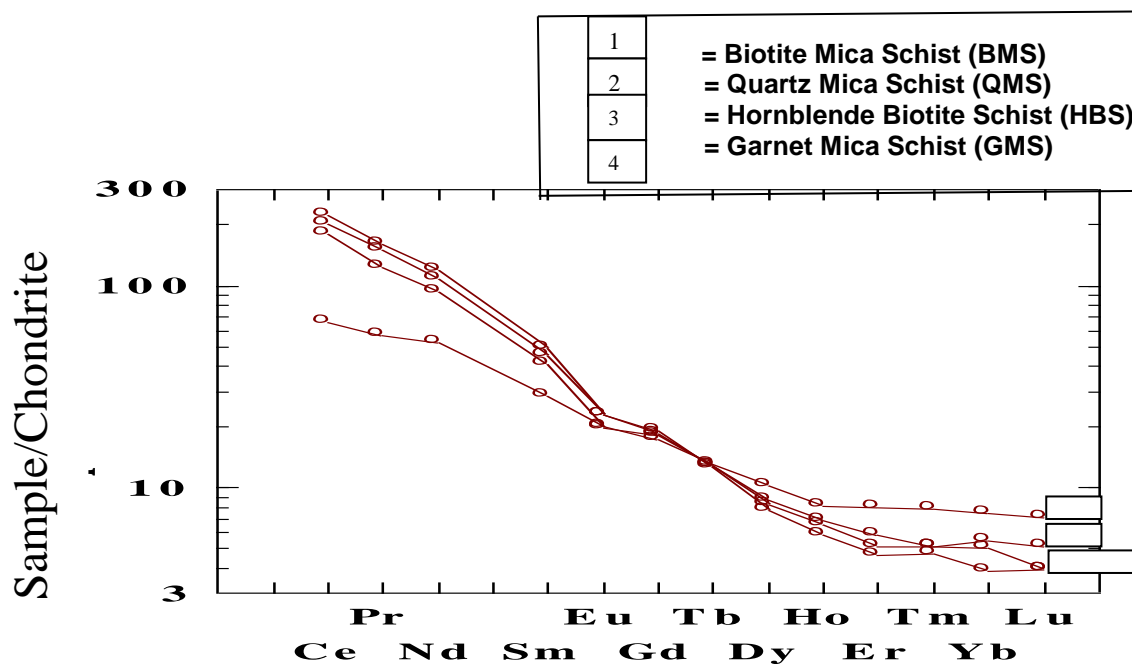


Fig. 8: REE versus Chondrite normalized sample plot of Schists of Northwest Obudu Plateau, Southeastern Nigeria.

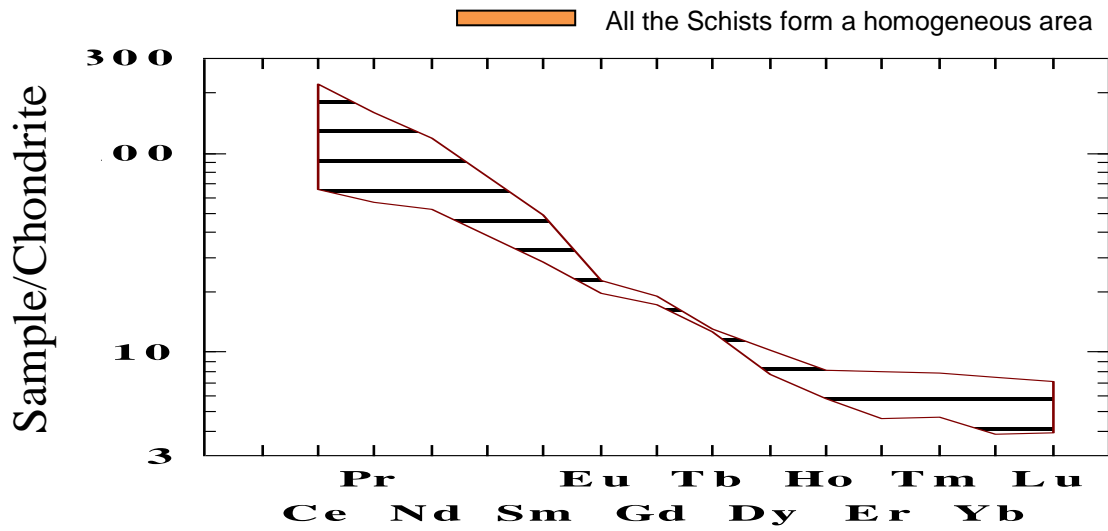


Fig. 9: REE versus Chondrite normalized area plot of Schists of Northwest Obudu area, SE. Nigeria. Shows a homogeneous area indicating intimately related protoliths.

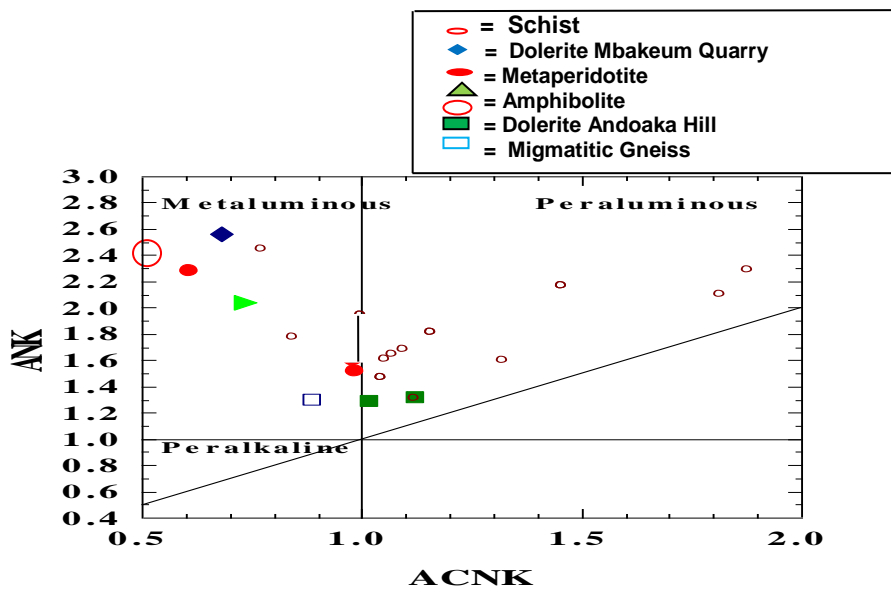


Fig. 10: ACNK vs ANK binary diagram for Discrimination of rocks of Northwest Obudu Plateau (Modified from Obioha, 2014)

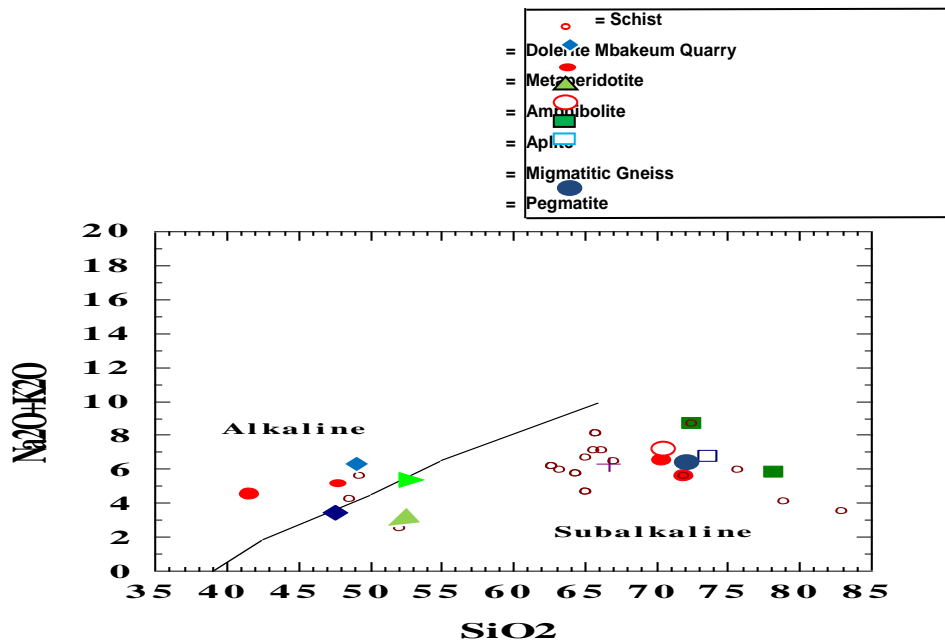


Fig. 11: SiO_2 vs $\text{Na}_2\text{O}+\text{K}_2\text{O}$ binary discriminant for rocks of Northwest Obudu Plateau Southeastern Nigeria (Modified from Obioha, 2014).

5.0 CONCLUSIONS AND RECOMMENDATIONS

Petro-Geochemical investigation of rocks of Northwest Obudu area Southeastern Nigeria, has shown a high grade metamorphic terrain that has been subjected to polyphase deformations and metamorphism, with occurrences of gneisses, schists, amphibolites and intruded by granites, granodiorites, aplites and gabbros (Obioha, 2014). The field study shows that the schists comprised quartz mica schist QMS, biotite mica schist BMS, and hornblende biotite schists (HBS) of peraluminous to subalkaline composition (Obioha and Ekwueme, 2012). Trace element geochemistry shows that the Ba concentration ranged from 1803ppm in the QMS to 1814ppm in the BMS, with average of 995.67ppm. These Ba concentrations are about 2 to 12 times the crustal threshold of Ba (400ppm Taylor, 1965), 150ppm in basalt and 550ppm in andesite.

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