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Geochemical and Petrographic Studies of Some Quartz Mica Schists in Igarra and Environs, Southwestern Nigeria

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ABSTRACT

Five schist samples from Igarra and Environs in Akoko Edo area of Southwestern Nigeria were obtained with the aim of determining their geochemical properties using XRF techniques and also for petrographic analysis. Results from the geochemical analysis revealed the presence of SiO_2 (54.65-59.01wt.%), Al_2O_3 (21.98-25wt.%), Fe_2O_3 (3.77-5.67wt.%), MgO (0.56-1.68wt.%), K_2O (4.62-6.56wt.%) and Na_2O (0.48-0.96wt.%). The geochemical evaluation revealed that the schists were probably generated from the metamorphism of shale. Discrimination diagrams show peraluminous character and plots within the metasedimentary field which also supports a sedimentary protolith. The A-CN-K plot reflects that the shale suffered moderate chemical weathering before being subjected to metamorphism. The petrographic studies also revealed the characteristics of the minerals present in the rock which shows the alignment of platy minerals in a preferred direction that aided the characteristic features of the rock foliation. Modal composition shows mineralogical assemblages of quartz + plagioclase + microcline + biotite + muscovite + hornblende which indicates that the schist belong to the greenschist facies grade.

1. Introduction

Schist is a medium-grade metamorphic rock formed from mudstone or shale. Schist has medium to large, flat, sheet-like grains in a preferred orientation (nearby grains are roughly parallel). It is defined by having more than 50% platy and elongated minerals (such as micas or talc), often finely interleaved with quartz and feldspar (Bishop et al., 1999).

These lamellar (flat, planar) minerals include micas, chlorite, talc, hornblende, graphite. Quartz often occurs in drawn-out grains to such an extent that a particular form called quartz schist is produced. Schist is often garnetiferous. Schist forms at a higher temperature and has larger grains than phyllite (Marshak et al., 2009). Foliation (metamorphic alignment in layers) with medium to large grained flakes in a preferred sheet-like orientation is called schistosity. The names of various schists are derived from their mineral constituents.

According to Oyebamiji and Okunlola (2016), the schist often occurs as layered relicts, lensoidal or pools of pods. Most of the original sedimentary features have been obliterated by poly phase metamorphism. They are mainly quartz mica schists, mostly light brownish to dark grey in colour. They are exposed sporadically within the pervasive pegmatite zone in virtually the whole area as horizontally dipping oral bodies inter layered with the rare metal bearing pegmatite.

The Basement Complex of Nigeria lies within the Pan African mobile belt to the east of West African Craton and northwest of the Gabon Congo Craton. The complex is broadly classified into two provinces; the western Province which comprises mainly narrow metasediments (schists) which trend N-S. The schist in this province form schist belt which also includes other rocks mainly migmatite, gneiss, marble which were intruded by Pan-African granitic plutons. The eastern Province comprises the migmatite gneiss complex which is being intruded by larger volumes of Pan-African granite with the Mesozoic ring complexes of central Nigeria (Ajibade and Wright, 1988).

This research work is aimed at determining the geochemical properties and also carryout petrographic studies of the schist in Igarra and environs, southwestern Nigeria. The study area lies in the northern part of Edo State between latitude 7°9'47"- 7°19'35" and longitudes 6°5' 53"- 6°13'30" (Figs. 1 and 2).

2. Geologic Setting

Igarra area is located along Auchi-Ibillo road at latitude of 7.33784 North and longitude of 6.13970 East. It is a town located in the northern part of Edo-State, Nigeria (Fig. 2). Its topography is mountainous and situated in the lee-wind side of the Kukuruku-hill an area of 1371 km^2. Igarra area, lies within the southwestern Nigeria basement which itself is a part of the Nigerian Basement Complex.

The Nigerian Basement Complex is also a part of the Pan African mobile belt that lies between the West African Craton to the east and the Congo Craton to the southwest within the African continent. The area is underlain by metasediments, referred to as the Igarra Schist Belt, which presumably overlies an older gneiss-migmatite basement, possibly of Liberian age (Odeyemi, 1976). The metasedimentary succession in Igarra area consists predominantly of pelitic to semi-pelitic rocks of low to medium grade metamorphism. Major rock types exposed in the area include (i) Semi-pelitic phyllites; (ii) Quartz-biotite schists (iii) Mica schists (iv) Calc-silicate gneisses and Marbles and (v) Metaconglomerates; all of which have been deformed in at least two episodes (Odeyemi 1988).

These supracrustal rocks and the underlying basement were subsequently intruded by Pan African granites such as the Igarra Batholiths and other minor intrusive including pegmatites, aplites, dolerites, lamprophyres and syenites. The Igarra region is underlain by rocks of the Precambrian Basement Complex (Fig. 2) and about four major groups have been observed within this area which include; migmatite-gneiss complex, the metasediments (schists, calc-silicate rocks, quartzites, marbles, metaconglomerates), the porphyritic older granite which are discordant, non-metamorphosed syenite dyke (Odeyemi, 1976).

The major rock in the study area include biotite hornblende granites, psammite pelite sequence, metaconglomerates, calc-gneisses and marbles, and quartz mica schists which occupies about 20% of the study area (Fig. 3).

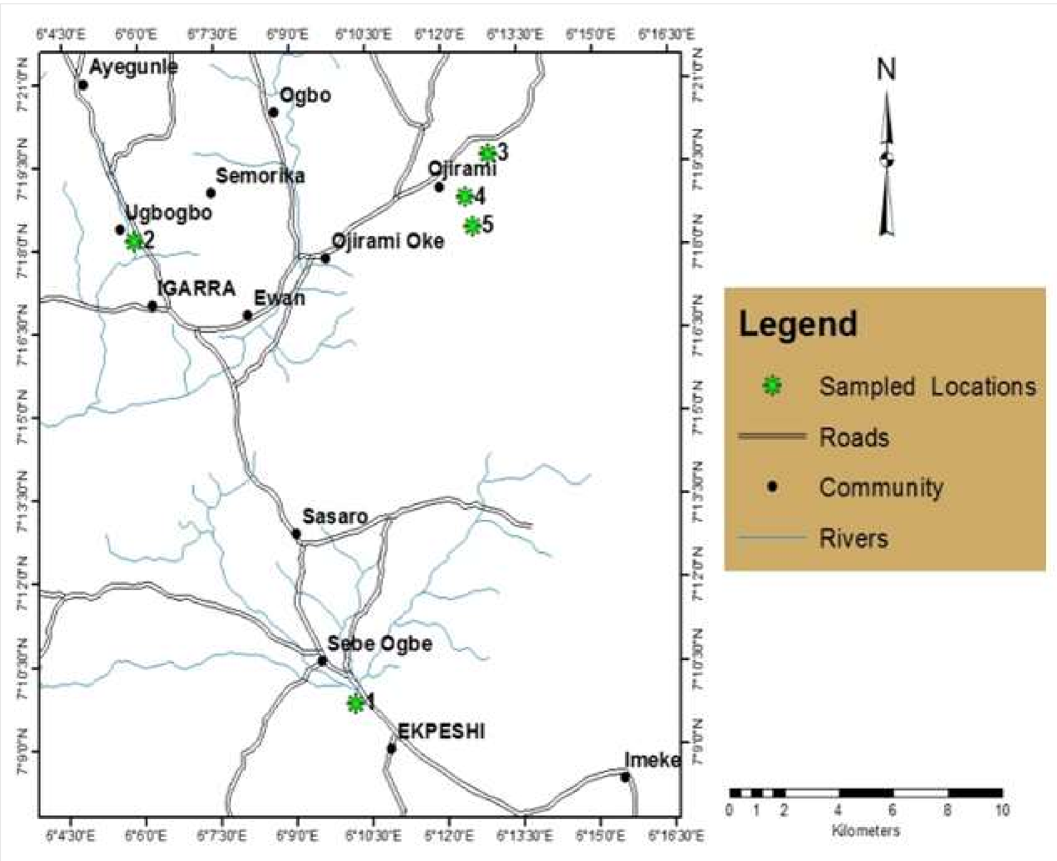

Fig. 1. Map of study area showing the sampled locations

3. Materials and Methods

3.1. Sampling

Five rock samples of schist were obtained at different locations by random sampling method, to avoid bias, well-labeled and taken to the laboratory and were subjected to X-ray Fluorescence (XRF) analysis using model 1200 ARL ADVANT'X THERMOSCIENTIFICS at National Steel Raw Materials Exploration Agency (NSRMEA) Kaduna, Nigeria. Also, thin sections were prepared from representative rock samples taken from the field and used for petrographic studies, using a petrographic microscope with model XSZ-107BN at the Thin Section Laboratory, Department of Geology, University of Ibadan, Ibadan, Oyo State.

3.2. Thin section petrography

Samples obtained from the field were selected and prepared for petrographic studies. The rock samples were cut with a diamond cut-off saw to obtain a flat surface with the size of the microscopic preparation that is required. It was polished to eliminate the traces of cutting and to obtain a flat surface. The polished surface was stuck onto a glass microscope slide with a colourless and isotropic cementing agent.

After the sample has been stuck to the microscope slide, which was cut to obtain the thinnest slice and trimmed until it had a thickness of about 30 microns such that light can pass through. It was carefully cleaned and covered with a slide cover, which was stuck with a similar cement to the one used to stick the sample to the slide.

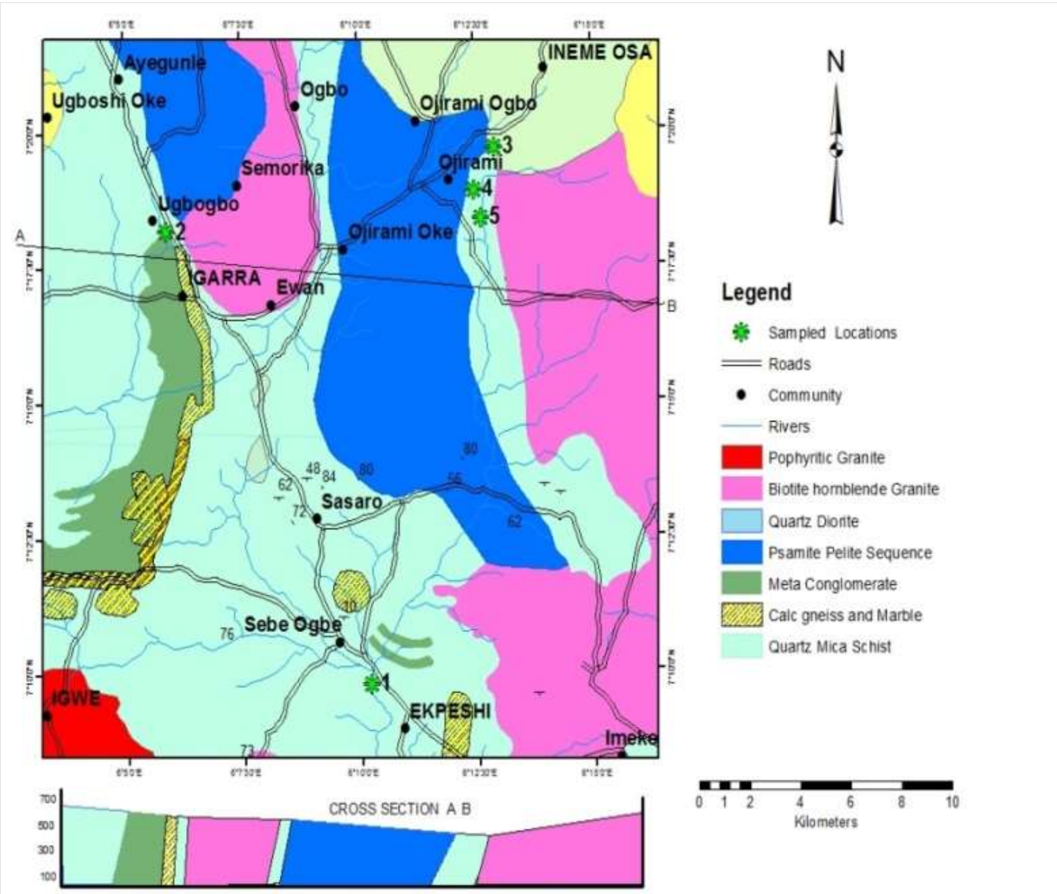

Fig. 2. Geological map and cross section of study area

Table 1. Modal composition of the mica schist from study area

Sample	Q	MIC	P	B	H	M	O
IK1	28.0	19.2	26.5	16.1	4.5	5.1	0.6
UG2	29.2	20.0	28.2	13.5	4.3	4.1	0.7
OJ3	26.6	18.4	25.5	19.8	3.7	5.2	0.8
OJ4	27.1	20.2	26.6	17.3	3.1	5.0	0.7
OJ5	26.2	22.3	27.5	14.2	4.3	4.9	0.6
IDs	40	13.7	8.15	13.15	---	18.45	6.45
OBs	21	---	19	20	1	16	----

*Q=Quartz, MIC= Microcline, P= Plagioclase, B= Biotite, M= Muscovite, O= Opaque, **Bolded Samples** = Study area, IDs = Idaoni Schist, OBs = Obudu Schist*

3.3. X-ray Fluorescence Analysis

Fresh rock samples of schist were crushed and then pulverized using Herzog Gyro-mill. Pellets were prepared from pulverized sample by grinding 20 g of each sample with 0.4 g of stearic acid for 60 seconds. After grinding, the mill was cleaned to avoid contamination. One gram of stearic acid was weighed into an aluminum cup to act as a binding agent and the cup was subsequently filled with the sample to the level point. The cup was then taken to Herzog pelletizing equipment where it was passed at a pressure of 200 kN for 60 seconds. The 2 mmn pellets were added into a sample holder of the equipment for analysis.

4. Presentation and Discussion of Results

The petrographic and the geochemical analysis result of the representative samples are represented in Tables 1 and 2, respectively.

4.1. Petrography

Petrographic analysis result (Table 1) revealed that the schists in the study area contain quartz (26.2-29.2%), biotite (13.5-19.8%), muscovite (4.1-5.2 %), plagioclase (25.5-28.2%), microcline (18.4-22.3%), hornblende (3.1-4.5) and opaque minerals (0.6-0.8%). As observed under the microscope, the photomicrograph of sample IK1 reveals the alignment of mafic minerals (biotite, hornblende) indicating its flaky habit (Fig. 3) and also, the felsic minerals (quartz and plagioclase) are seen to align in the same direction showing segregation banding of dark and light coloured minerals which reflects the foliation trend of the rock.

Figs. 4-6 shows a granoblastic texture where the mineral grains present are all of even sizes. Biotite grains (Fig. 5) occurs as platy and bladed mineral showing preferred direction as the grain appears stretched along the foliation plane. Alternation of fine-medium grained quartz with medium-coarse grained micas is appreciated in Fig. 7.

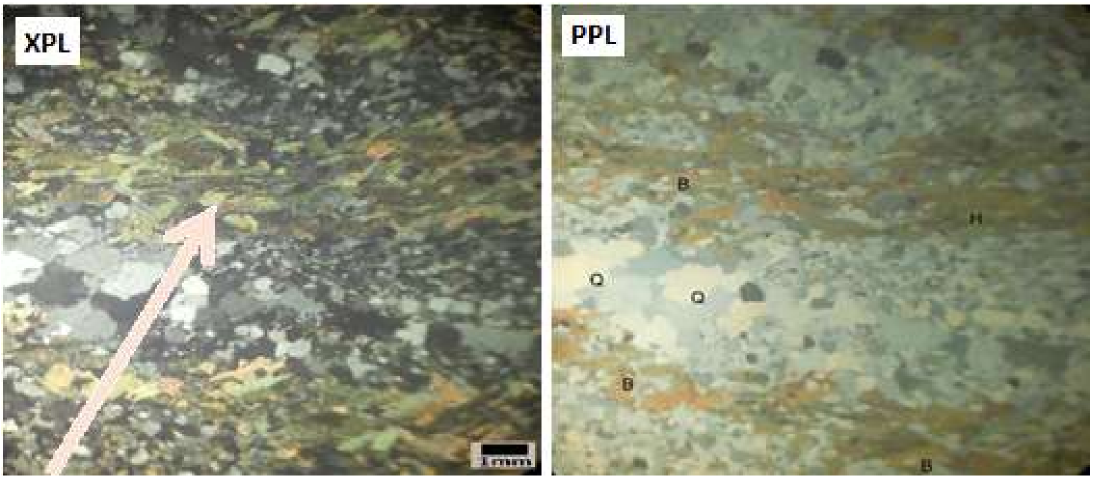

Fig. 3. Photomicrograph of Schist at Ikpeshi under PPL and XPL (Magnification x40) showing segregation banding of dark and light minerals and alignment of biotite indicating its flaky habit (Q = Quartz, B = Biotite, H = Hornblende)

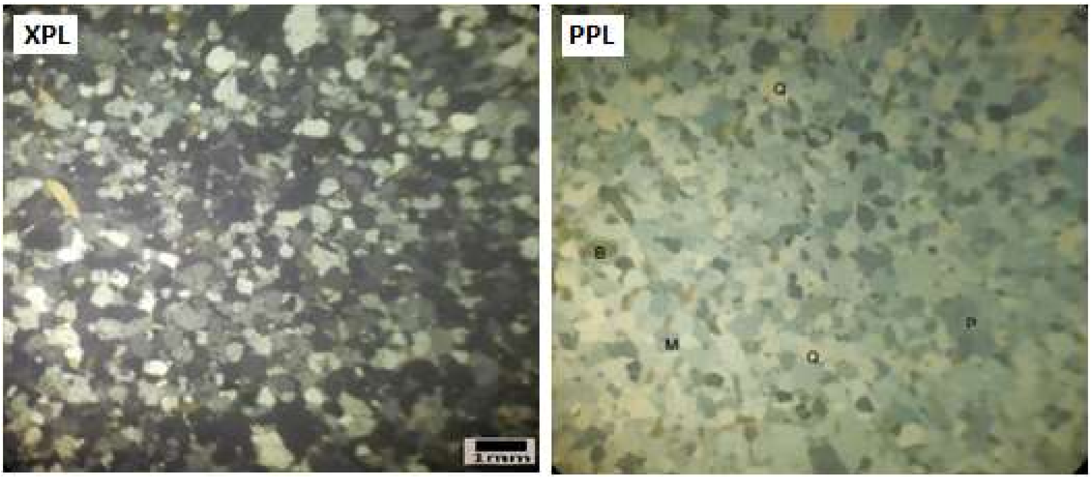

Fig. 4. Photomicrograph of a mica schist at Ugbogbo under PPL and XPL (Magnification x40) in which the mineral grains show a granoblastic texture (Q = Quartz, B = Biotite, M = Muscovite, P = Plagioclase)

Plagioclase appears colourless and has a low relief. It does not exhibit pleochroism and has anhedral crystal form (Fig. 7). The biotite appears brown with moderate relief and it exhibits pleochroism from light brown to dark brown and it is characterized with a perfect basal cleavage (Fig. 5). Quartz is a colourless mineral showing subhedral-anhedral crystal form in most of the samples. It exhibits no cleavage and pleochroism and are of a low relief and birefringence. Opaque minerals appear black both in PPL and XPL because of their inability to transmit light (Figs. 3-7). The schists consist of the mineralogical assemblages of quartz + plagioclase + microcline + biotite + muscovite + hornblende which show low to medium temperature and pressure condition indicating greenschist facies grade.

Other minerals such as chlorite, epidote also belong to the greenschist facies grade of metamorphism, although not captured in the thin section slide. In comparison with Obudu

Schist with mineralogical assemblage of quartz – garnet – plagioclase – sillimanite ± hornblende indicates that the schist had been metamorphosed at least up to the uppermost amphibolite facies grade.

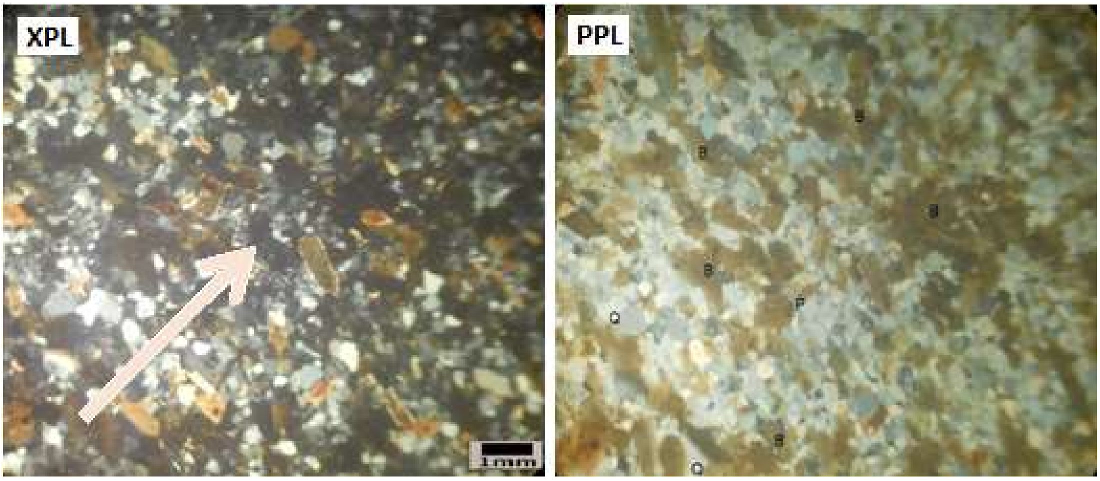

Fig. 5. Photomicrograph of a mica schist at Ojirami 3 under PPL and XPL (Magnification x40) showing a grain of biotite with the longer axis pointing the direction of the foliation pattern (Q = Quartz, B = Biotite, P = Plagioclase)

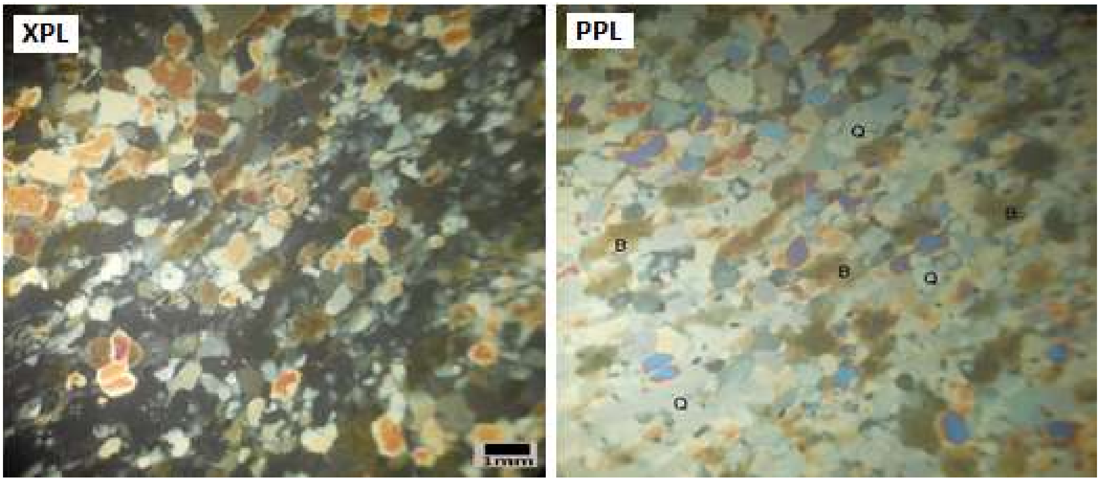

Fig. 6. Photomicrograph of mica schist at Ojirami 4 under PPL and XPL (Magnification x40) which shows granoblastic texture of the mineral grains. (Q = Quartz, B = Biotite)

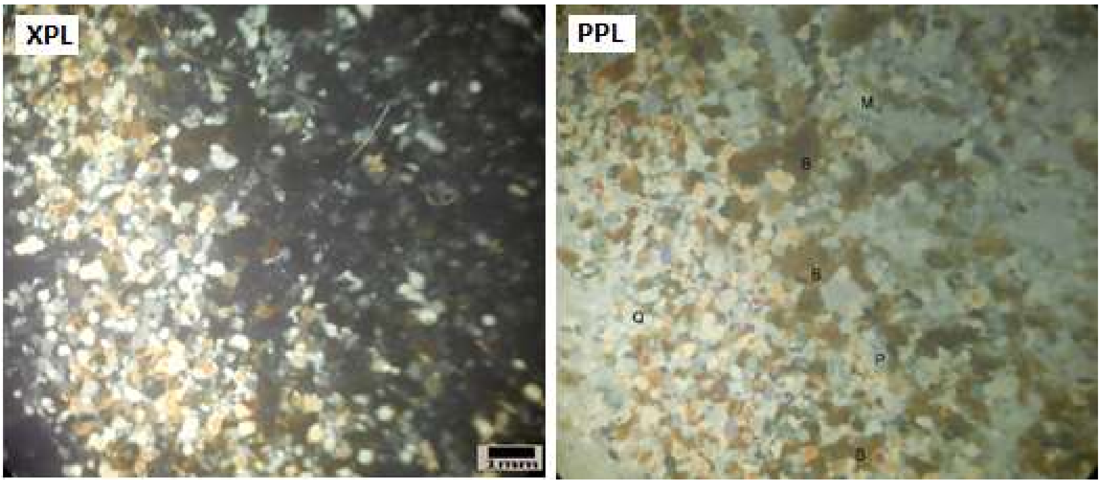

Fig. 7. Photomicrograph of a mica schist at Ojirami 5 under PPL and XPL (Magnification x40) showing alternation of fine-medium grained quartz with medium to coarse grained mica. (Q = Quartz, B = Biotite, P = Plagioclase, M = Muscovite)

Table 2. Major element compositions of mica schist from study area

No	Major oxides	IK1	UG2	OJ3	OJ4	OJ5	This study	IDS	WOS	IGS	OBS	MAS
1	SiO_2	55.40	57.40	59.01	55.91	54.65	**56.47**	68.89	62.6	69.7	62.94	66.97
2	Al_2O_3	24.50	25.00	21.98	27.04	24.74	**24.65**	13.10	14.6	14.84	17.13	15.44
3	Fe_2O_3	4.60	3.77	5.01	4.99	5.67	**4.81**	7.65	9.6	7.51	5.40	5.60
4	MgO	0.70	0.56	0.75	1.68	0.62	**0.86**	0.67	3.3	0.69	2.26	1.65
5	CaO	1.62	1.50	1.49	1.53	1.29	**1.49**	1.01	0.9	1.00	2.11	0.09
6	Na_2O	0.57	0.50	0.56	0.96	0.48	**0.61**	1.19	0.4	1.18	3.46	0.22
7	K_2O	6.56	6.02	5.21	4.62	6.12	**5.71**	2.26	8.8	3.80	3.66	4.37
8	TiO_2	0.77	0.54	0.66	0.68	0.74	**0.68**	-	1.2	-	0.67	0.56
9	MnO	0.10	0.13	0.15	0.12	0.11	**0.12**	0.03	0.5	0.09	0.06	0.09
10	P_2O_5	0.08	0.05	0.06	0.09	0.10	**0.08**	-	0.4	-	0.13	0.04
11	SO_3	0.05	0.07	0.04	0.06	0.06	**0.28**	-	-	-	-	-
12	V_2O_5	0.05	0.03	0.06	0.04	0.07	**0.05**	-	-	-	-	-
13	Cr_2O_3	0.05	0.05	0.02	0.04	0.03	**0.04**	-	-	-	0.01	0.04
14	Cl	0.36	0.33	0.42	0.41	0.22	**0.35**	-	-	-	-	-
15	BaO	0.05	0.03	0.03	0.06	0.04	**0.04**	-	-	-	-	-
16	Ag_2O	5.20	4.09	4.52	1.73	4.91	**4.09**	-	-	-	-	-
17	ZrO_2	0.04	0.02	0.03	0.04	0.05	**0.04**	-	-	-	-	-

IK1= Ikpeshi (Study Area), UG2= Ugbogbo (Study Area), OJ= Ojirami (Study Area), IDS= Idaoni Schist (Ondo State), WOs= Wonaka Schist Belt, IGs= Igarra Schist Belt, OBs= Obudu Plateau Schist, MAs = Malumfashi Schist, ***Bolded values*** *= study area mean value.*

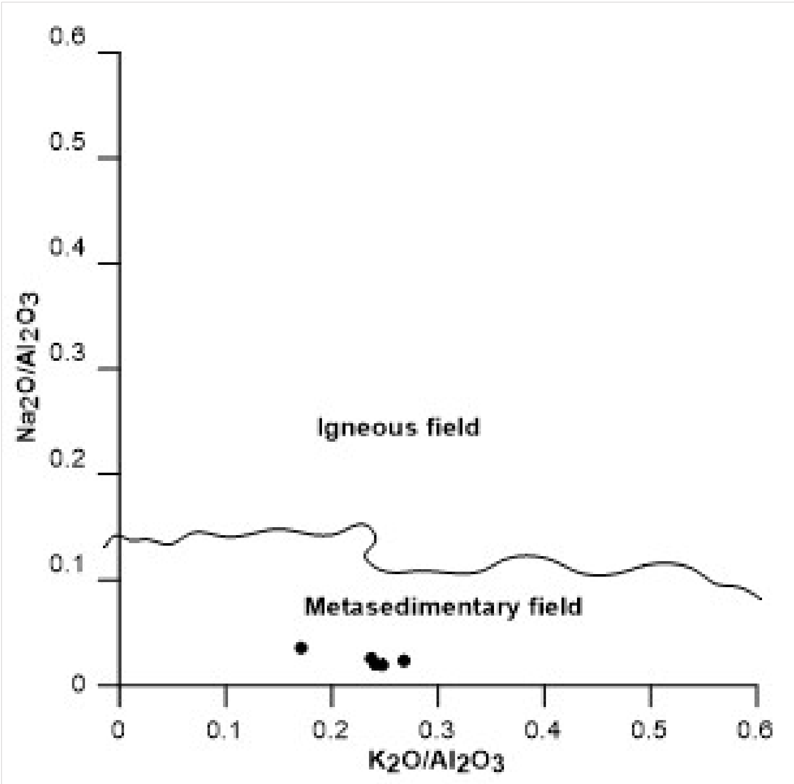

Fig. 8. Na_2O/Al_2O_3 versus K_2O/Al_2O_3 plot for some mica schist at Igarra (after Garrels and MacKenzie, 1971)

4.2. X ray Fluorescence results

The geochemical analyses result shows that all the analyzed schist samples from Igarra are enriched in silica (SiO_2) ranges from (54.65-59.01) wt.% with an average of 56.47wt.%. High alumina (Al_2O_3) content ranges from (21.98-25.00) wt.% as a result of high amount of feldspar reflecting pelitic nature of the schist.

The Fe_2O_3 content varies from (3.77-5.67) wt.%, MgO from (0.56-1.68) wt.%, K_2O from (4.62-6.56) wt.% and Na_2O from (0.48-0.96) wt.% respectively. The quartz mica schist of the study area has lower silica content compared to the Idaoni, Wonaka, Obudu and Malumfashi Schist which is probably as a result of the amount of quartz present in the samples and other silicates minerals (Table 1).

The study area shows higher Al_2O_3 contents than those of Idaoni, Wonaka, Obudu and Malumfashi Schist (Adegbuyi et al., 2017; Usman and Ibrahim, 2017; Obioha and Ekueme, 2012; Alaku et al., 2017) which indicates higher peraluminous content, due to the presence of aluminosilicate minerals in the rock sample. The study area has higher total alkali (Na_2O+ K_2O) contents than that of Idaoni, Malumfashi and Igarra Schist but lower than the Wonaka and Obudu Schist (Adegbuyi et al., 2017; Alaku et al., 2017; Usman and Ibrahim, 2017; Obioha and Ekueme, 2012).

A discrimination diagram of Garrel and McKenzie (1971) indicates that the Igarra Schist plots within the metasedimentary field which suggests a sedimentary protolith (Fig. 8).

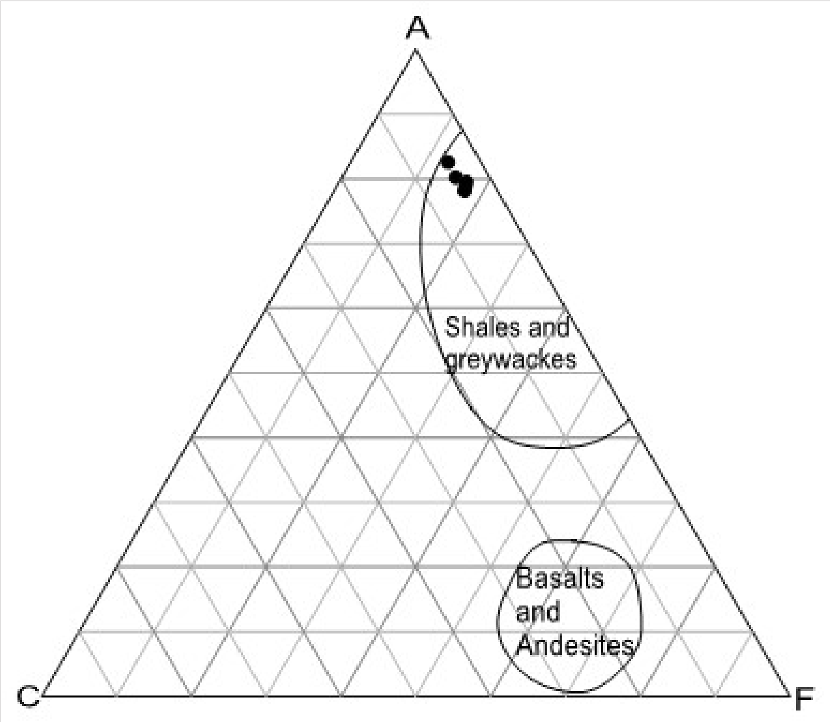

Fig. 9. ACF diagram for Mica Schist in Igarra (after Miyashiro, 1973)

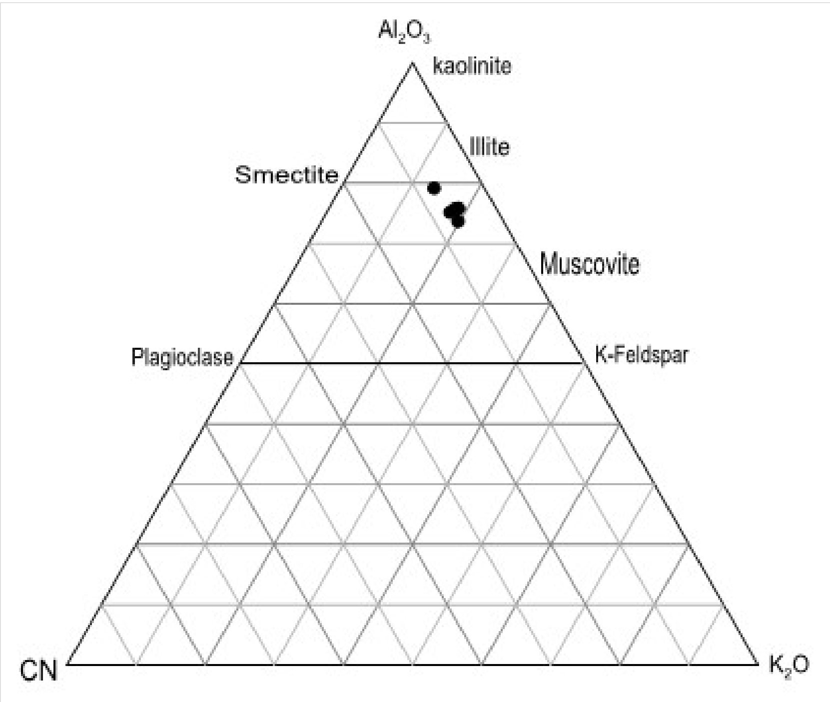

Fig. 10. A-CN-K diagram showing the weathering trend of the Mica Schist in Igarra (after Nesbitt et al., 1982)

In the ACF diagram of Miyashiro (1973), the quartz mica schist plotted in the field of shale-greywackes, which suggest a shale protolith (Fig. 9). A plot of Nesbitt and Young (1982) shows the weathering trend of the schist on the A-CN-K ternary diagram, in which the sediments plotted close to the A-K axis indicating that the sediment has undergo moderate chemical weathering (Fig. 10). Some of the schist in Igarra shows peraluminous nature (Fig. 11) when plotted on the molecular diagram of Maniar and Piccoli (1989). This is probably as a result of the high alumina content.

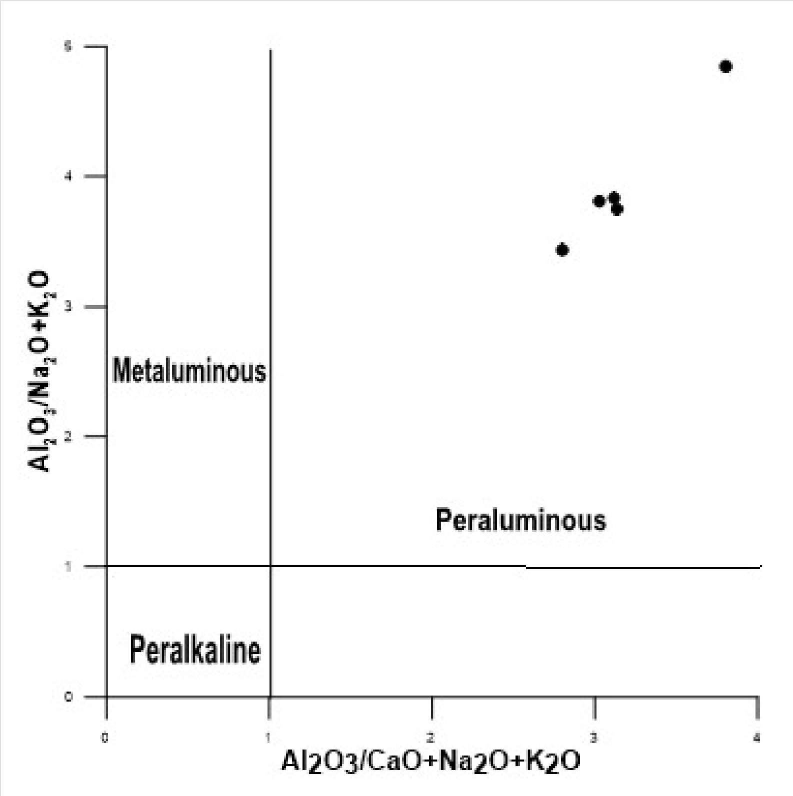

Fig. 11. Al_2O_3/ $CaO+K_2O$ versus $Al_2O_3/CaO+Na_2O+K_2O$ molecular plot for Mica Schist in Igarra area (after Maniar and Piccoli, 1989)

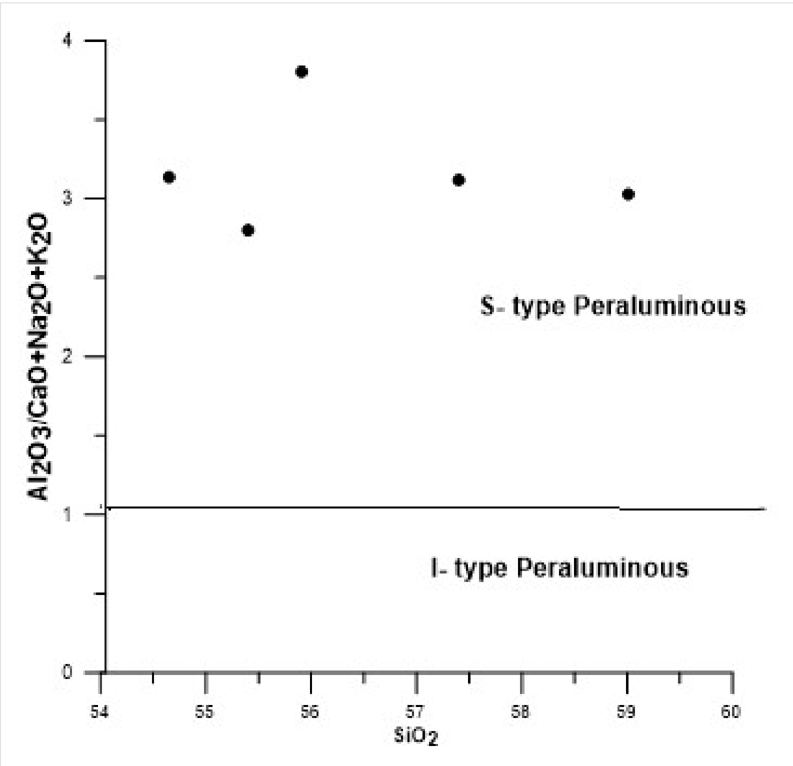

Fig. 12. $Al_2O_3/(CaO+Na_2O+K_2O)$ versus SiO_2 plot for Mica Schist in Igarra (after Dombrowski et al., 1995)

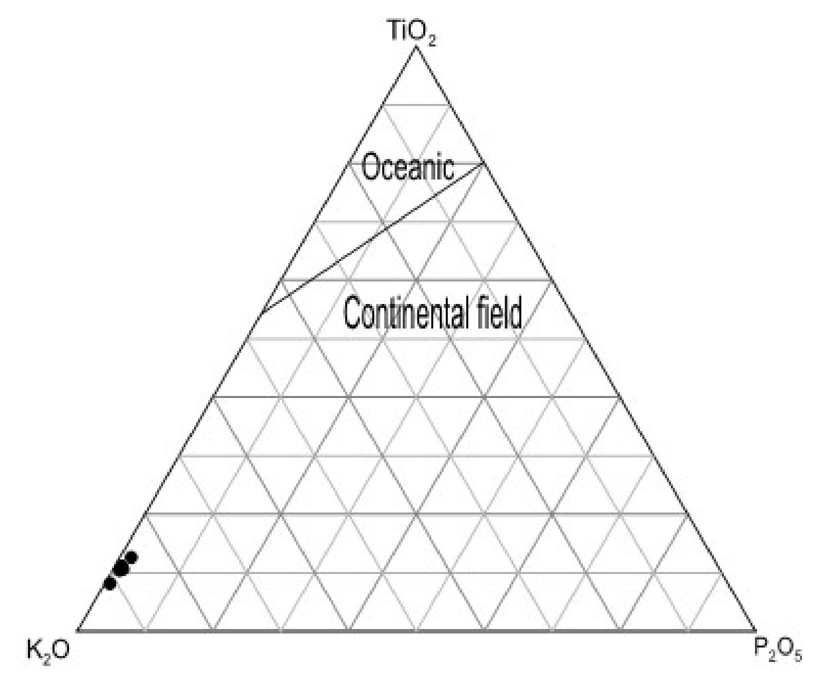

Fig. 13. TiO_2-K_2O-P_2O_5 diagram for the Mica Schist at Igarra (after Pearce et al., 1975)

Also, it shows an S-type peraluminous on the plot of Dombrowski et al. (1995) which suggest that the peraluminous nature of the schist is of sedimentary origin (Fig. 12). The TiO_2-K_2O-P_2O_5 plot after Pearce et al. (1975) confirms that the sediments of the quartz mica schist are of a continental nature (Fig. 13).

The discriminant diagrams of the study area as compared with those of the Idaoni, Wonaka, and Malumfashi schist after Adegbuyi et al. (2017), Usman and Ibrahim (2017) and Alaku et al. (2017), respectively, are similar which suggests that the schists are probably of sedimentary origin and of peraluminous characteristics.

Significant percentage of K_2O in study area shows that the samples have undergone moderate weathering and are not as intense as compared with Malumfashi schist which suffered moderate to intense chemical weathering. This is explained in the A-CN-K plot (Nesbitt and Young, 1982) which shows that the K-feldspar in the study area has not altered into clay minerals (Fig. 10) while some of the sediment of Malumfashi schist have been altered to clay mineral (illite) which indicates the maturity of the sediments (Alaku et al., 2017)

5. Conclusion

Several plots have been used to characterize the composition and origin of some quartz mica schist of Igarra and environs. The geochemical and petrographic evaluation revealed that the schists were probably generated from the metamorphism of shale. Discrimination diagrams show peraluminous character and plots within the metasedimentary field which also supports sedimentary protolith. The A-CN-K plot reflects that the shale suffered moderate chemical weathering before being subjected to metamorphism. The petrographic studies also revealed the characteristics of the minerals present in the rock which shows the alignment of platy minerals in a preferred direction that aids the characteristic features of the rock, foliation. Modal composition shows mineralogical assemblage of quartz + plagioclase + microcline + biotite + miuscovite + hornblende which indicates that the schists belong to the greenschist facies grade.

References

Adegbuyi, O., Ogunyele A.C., Odindu, M., Erinfolami, T.G., 2017. Geochemical characteristics and petrogenesis of Basement rocks in Idoani Area, Ondo State, Southwestern Nigeria. International Journal of Advances Geosciences 5, 102-108.

Ajibade, A.C., Wright, J.B., 1988. Structural Relationship in the Schist Belts of North Western Nigeria. In P.O Oluyide et al (Eds). Precambrian geology of Nigeria. A Publication of Geological Survey, pp 103-109.

Alaku, O.I., Moshood, I.O., Agbor, T.A., Amos, A.A. 2017. Geochemical Characteristic and Petrogenesis of Malumfashi Schist around Tandama Area, North-Western Nigeria. British Journal of Applied Science & Technology 20 (1), 1-14.

Bishop, A.C., Woolley, A.R., Hamilton, W.R., 1999. Cambridge Guide to Minerals, Rocks and Fossils. Cambridge University Press. p. 153. Essentials of Geology, 3rd Ed, Stephen Marshak.

Dombrowski, A., Henjes-Kunst, F., Hohndorf, A., Kroener, A., Okrusch, M., Richter, P., 1995. Orthogneisses in the Sperssart Crystalline Complex, north-west Bavaria: Silurian granitoid magmatism at an active continental margin. Geologic Rundschau. Vol. 84, 399-411.

Garrel, R.M., Mackenzie, F.T., 1971. Evolution of Sedimentary Rocks. W.W. Norton and Co. Int. New York, 394 p.

Maniar, P.D., Piccoli, P.M. 1989. Tectonic discrimination of granitoids. Geological Society of America Bulletin 101, 635-643.

Marshak, S., Wilkerson, M.S., Wilkerson, M.B., 2009. Essentials of Geology(3rd ed.). W.W. Norton.

Miyashiro, A., 1973. Metamorphism and metamorphic belts. George Allen & Unwin Ltd. London, 492.

Nesbitt H.W., Young G.M., 1982. Early Proterozoic climates and plate motions inferred from major element chemistry of lutites. Nature 299 (5885), 715-717.

Obioha, Y.E., Ekueme, B.N., 2012. Geochemistry of Schists of Northwest Obudu Plateau, Southeastern Nigeria. Global Journal of Geological Sciences 10, 157-165.

Odeyemi, I.B., 1976. Preliminary report on the field relationships of Basement complex rocks around Igarra, Mid-Western State, Nigeria: Geology of Nigeria. University of Ife, Nigeria.

Odeyemi, I.B., 1988. Lithostratigraphy and structural relationships of the Upper Precambrian Metasediments in Igarra area, southwestern Nigeria.

Oyebamiji, A.O., Okunlola, A.O., 2016. Geochemical Evaluations and Economic Potentials of Rare Metal Pegmatites in Iludun area, Southwestern Nigeria. IQSR Journal of Applied Geology and Geophysics 4, 72-78.

Pearce, M., Gorman, B.E., Birkett, T.C., 1975. The relationship between major element chemistry and tectonic environment of basic and intermediate volcanic rocks. Earth and Planetary Science Letters 36 (1), 121-132.

Usman, M.A., Ibrahim, A.A., 2017. Petrography and geochemistry of rocks of Northern part of Wonaka Schist Belt, Northwestern Nigeria. Nigerian Journal of Basic and Applied Science 25 (2), 87-99.