Petrographic Characteristic and Geochemical features of Basement Rocks in Ikogosi, Southwestern Nigeria.

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DOI: https://doi.org/10.56293/IJASR.2022.5441

IJASR 2022
VOLUME 5
ISSUE 5 SEPTEMBER - OCTOBER **ISSN: 2581-7876**

Abstract: This study investigates and reports petrographic characteristics, geochemical features and the processes of formation of rocks in Ikogosi, southwestern Nigeria. Eighteen (18) rock samples (six quartzite, six migmatite gneiss and six schists) were collected and subjected to optical study. Ten (10) representative samples (six quartzite, three schist and one migmatite gneiss) were evaluated for major elements composition using Energy Dispersive X-Ray Fluorescence (ED-XRF). Petrographic evaluation revealed quartz, feldspar, muscovite, biotite, hornblende, pyroxene and opaque are dominant mineral constituents in quartzite and schist while migmatite gneiss contains the same set of minerals but without opaque constituents. Quartz forms a dominant constituent in quartzite and migmatite gneiss but as subordinate mineral in the schist. The feldspars are mainly plagioclase with albite twinning, associated microcline has characteristic crosshatched twinning. Chemical investigation reveals the rock units are generally siliceous. Three oxides (SiO2, Al2O3 and Fe2O3) constitute 85–90% of the bulk chemical composition of the rocks. SiO2 constituent as applied in rock classification indicates the quartzite is unequivocally felsic, migmatite is intermediate while the schist is mafic to ultramafic. K2O versus SiO2 variation plot revealed that the quartzite and schist are tholeiitic while the migmatite gneiss is shoshonitic. TiO2 versus SiO2 variation diagram depicts igneous antecedent.

Keywords: Ikogosi, petrographic, twinning, schist, shoshonitic, igneous antecedent

Introduction

Ikogosi and environs is underlain by crystalline rocks, the units are quartzite, migmatite-gneiss and schist with quartzite being the dominant. The Nigeria crystalline basement forms the oldest unit and constitutes one of the two petrological subdivisions of Nigeria. The other being Cretaceous-Recent sedimentary sequences unconformably overlying the basement. The components of crystalline basement are migmatite, the schist belts and Pan-African granite suites. The Basement rocks are made up of igneous and metamorphic rocks which underly the stratified rocks and are mostly of Precambrian age. Mineralogy and chemical composition of rocks constitute a reliable means of rocks' classification, while records of the various transformations are documented in the mineralogy and chemical dynamism of the rock (Talabi, 2013). Crystalline rocks are made of interlocking silicate minerals such as quartz, feldspars, micas, hornblende, pyroxenes, olivine and a host of minor accessories.

Several research works have been conducted on the petrography and geochemistry of basement rocks in Nigeria. Talabi (2013) worked on the mineralogical and chemical characterization of major basement rocks in Ekiti State and concluded that migmatite-gneiss, quartz-schist/quartzite, the Pan-African granites and charnockite were the major rocks types in Ekiti. Mineralogically, quartz and feldspar are dominant in most of the rock units. Gideon (2019) investigated the petrographic and geochemical characterization of basement rocks around Okene, North Central Nigeria. The author identified migmatite, granite, charnockite, hornblende biotite-gneiss, melanocratic banded-gneiss, leucocratic biotite-gneiss, quartzo-feldspartic gneiss and pegmatite dyke as the major lithologic units in the area. This study investigates the petrography and chemical characteristics of rocks around Ikogosi-Ekiti, to unravel the origin of the rocks using appropriate variation diagrams.

Location of the study area

Ikogosi is a small town in Ekiti West Local Government area of Ekiti State. The town is about forty-five kilometres from Ado-Ekiti, the Ekiti State Capital. It lies within northern part of Ogotun, western part of Ilawe-Ekiti, northwest of Igbara-Odo and southwest of Igede Ekiti. It lies between latitude 7°34' N and 7°35' N, longitude 4°58' E and 5°5' E (Fig. 1). Ikogosi is quite accessible, it contains motorable asphalted trunk B roads and the general area can be accessed by cars, tricycle or motorcycle. In addition, the area has a network of footpaths linking it to farm settlements. The general topography of the area is undulating, some parts of the area have deep valleys. The eleveation of the area as determined from digital elevation map varies from 473m in the valleys to 549m on the hills. The area is well drained, as some of the rivers have definite channels and mostly flow througout the year. Smaller streams are seasonal and exist only as dry channel at the peak of dry season. The study area falls within tropical rain forest zone of Nigeria, the area experiences two distinct seasons; rainy and dry seasons. The wet season is characterized by prevailence of moisture laden winds from the Atlantic Ocean while the dry season is hot and dusty North-East trade winds emernating from the Sahara desert. The area has annual rainfall of 1500 mm, high relative humidity ranging between 70 – 85% with average annual temperature of 28°C (Talabi, 2013). The natural vegetation of the area is dominated by emergent tall trees with canopies and vines around the undulating terrain of the rocky region in Ikogosi (Opeyemi et al., 2019). Ikogosi Ekiti is a rural town with linear settlement and total population of 3,594 (National Population Commission, 2006). Local populace are primarily engaged in primary occupations including farming, fishing, and crafts among others (Opeyemi et al., 2019). Ikogosi Ekiti is home for the famous Ikogosi Warm Spring Tourist Center, where cold and warm spring waters flow together. The warm and cold springs are situated in a valley surrounded by lofty hills which attract visitors to the tourist center for leisure, vacation, conference and educational research. Ikogosi is also the home of the 5-star chalets rooms and Gossy Water Bottling Industry, a subsidiary of United Africa Company, Nigeria (Opeyemi et al., 2019).

Geology of the study area

Ikogosi area cotains three major rock types, these are quartzite, migmatite-gneiss and schist (Fig. 2). Quartzite occupy major parts of the area and occurs in three types. These are massive quartzite, fissile quartzite and quartz mica schist. The quartzite, consequent on its resistance to weathering is of high elevation while the schict is low lying. Along the Ipole-Iloro road, there exist a geologic contact between quartzite and the migmatite-gneiss. Structural elements of the area include veins, veinlets, pegmatite dyke and joints, on a regional scale, the schist exhibits extensive schistosity.

Methods

Detailed geological mapping of Ikogosi area was undertaken and fresh samples of rocks were collected for petrographic and geochemical investigation. A summary of the procedure and methods adopted in this study are illustrated in the form of a flowchart (Fig. 3). Eighteen (18) fresh representative samples comprising of Six (6) samples each of quartzite, migmatite-gneiss and schists were obtained from outcrop exposures in the field (Fig. 4). The samples were collected from mine site, natural outcrops, at water fall areas and along river channels at different locations within the study area. The samples were protected from pre-test deterioration through effective bagging and subsequently subjected to petrographic analysis during which optical observation were conducted. During preparation of thin sections for the eighteen samples, a thickness of 1.0 cm of a square shape of the rock was cut using the cutting machine. By applying emery cloth and carborundum powder, the specimen was further grounded to a thickness of about 0.04 mm. This specimen was overlain by the boiled Canada balsam and covered with a slip and left for a day, and then it was washed, rinsed with spirit and later with water. Eighteen (18) thin sections were prepared from the samples for effective analysis and control. The thin sections were further subjected to petrographic studies using binocular microscope to view the major minerals in the samples. Photomicrographs of the samples were taken as shots. The major minerals in the photomicrographs were estimated to give a relative percentage of each mineral.

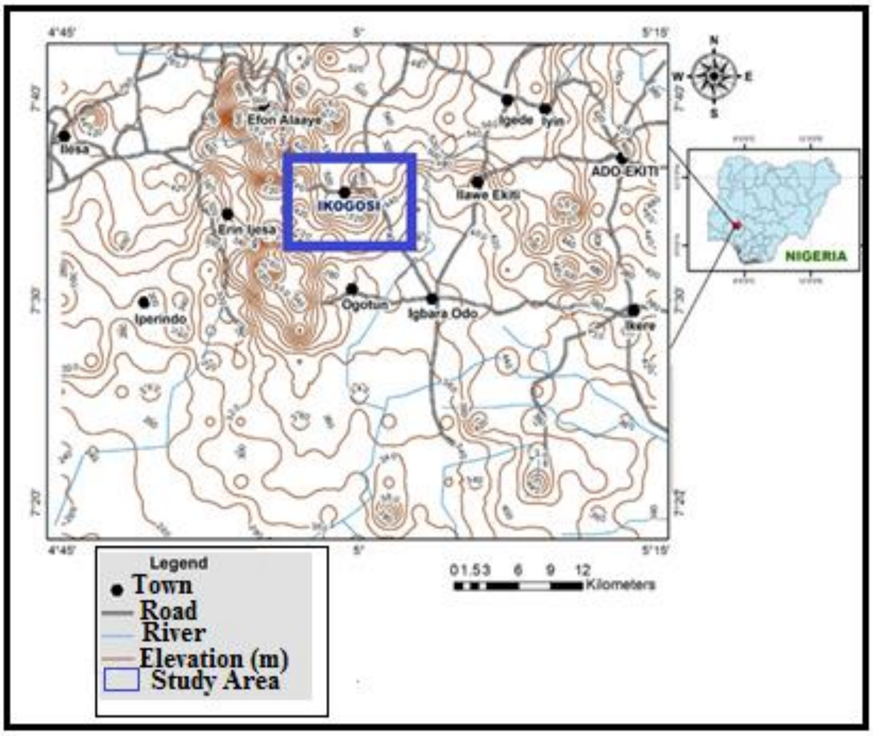

Fig. 1: Location map of the study area, the blue rectangle represents Ikogosi area.

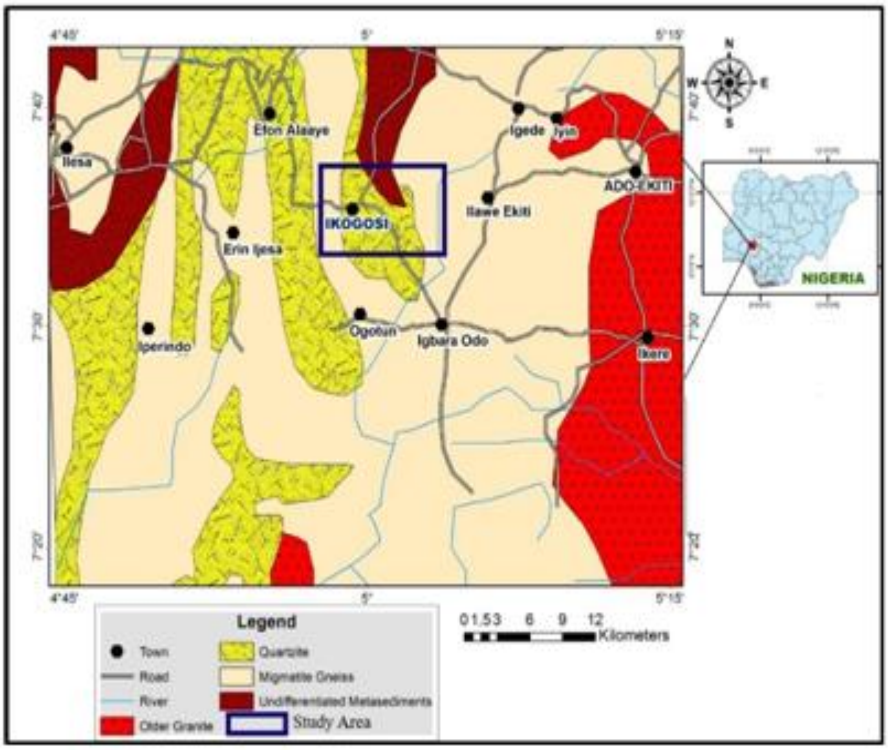

Fig. 2: Geological map of the study area.

On the other hand, the geochemical analysis was carried out on ten (10) selected fresh representative rock samples comprising of six quartzites, three schists and one migmatite gneiss using Energy Dispersive-X-Ray-Fluorescence (ED-XRF) equipment. Each of the specimens was crushed using the cone crusher, then into powder using the rock pulverizing device. The ED-XRF machine applies X-Ray Fluorescence analytical technique to determine the elemental composition of the various samples. Using this equipment, within 10 seconds, the main elements contained in software which highlights information such as measurement time, sample image for viewing each sample can be detected. The equipment also comes with easy to operate.

Results and Discussion

Field geology

Geological appraisal through systematic mapping revealed outcrops of quartzite represents high rising hills while migmatite-gneiss and schist are low-lying. The rocks are not evenly distributed but quartzite predominates covering a greater proportion of the study area. The migmatite-gneiss comprise of felsic and mafic minerals signifying the mixed nature of the rock. The felsic minerals contain quartz, orthoclase feldspar and muscovite. Quartz is colorless, white and occasionally grey in color while orthoclase displays white or grey color, muscovite is the flaky mineral of the mica group which is colorless. The mafic group comprise dominantly of biotite and hornblende. Biotite is flaky while hornblende is not but harder. The former has a hardness of 2–2.5 and can easily be scratched with a pen-knife while the later range of hardness is 5–6 on the Mohr's scale of hardness.

Schist

Shists originate from metamorphism of either igneous or sedimentary protolith. The schist in the study area contains different minerals in thin section. The schist outcrops prominently along Erinjiyan-Ikogosi road mainly as low lying units. It ranges from light-grey to reddish-brown in colour and are mostly coarse grained. These rocks comprise of minerals of economic importance such as manganese, tin, tourmaline, and copper (Fig. 4a). On outcrop scale, visible minerals in the rocks are quartz, feldspar, biotite and muscovite (Fig. 4b). Several geologic features are observed on these rocks, these include veinlets, veins, fractures. However, quartz vein is the commonest. The rocks dip towards east.

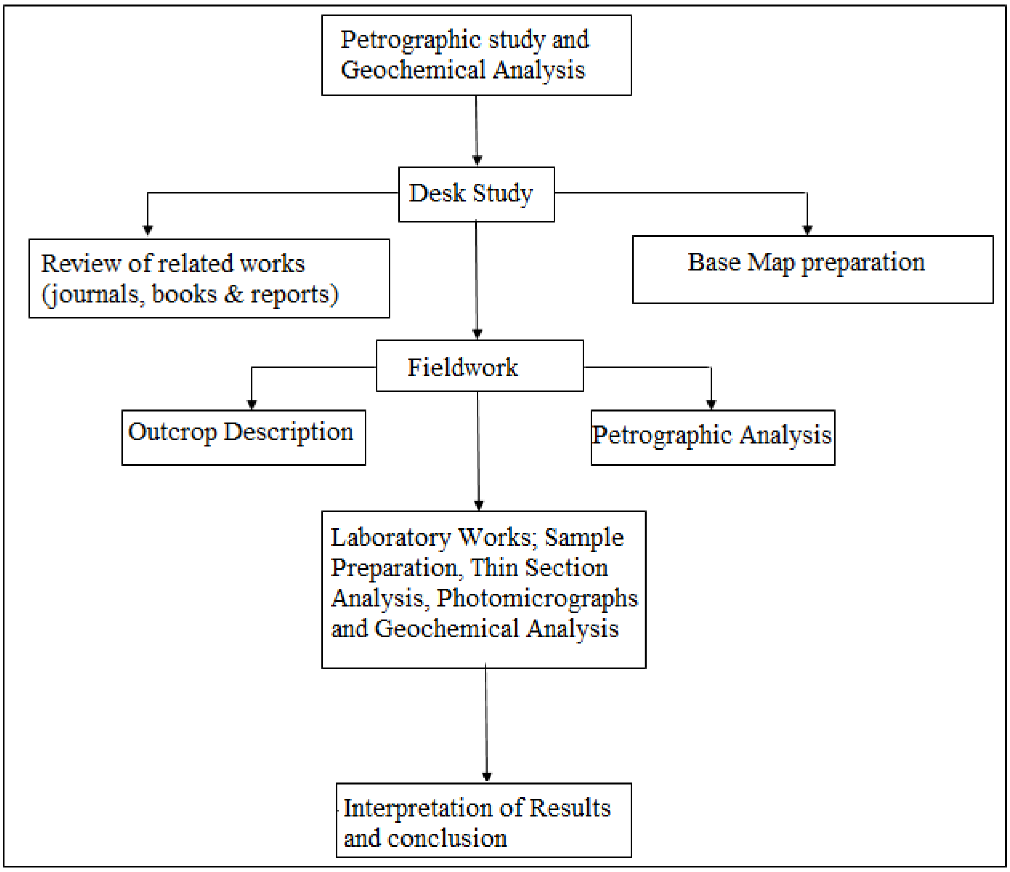

Fig. 3: Research workflow (after Chinwuko et al., 2020)

Quartzite

Quartzite is a metamorphic rock formed from sandstone or quartz stone. It is highly resistant and non-foliated metamorphic rock. Quartzites in Ikogosi are of three different types, these are massive quartzite, fissile quartzite and mica schist/quartzite. They are composed of quartz, feldspar, muscovite and biotite. Field observation also showed that the quartzite contain high quantity of feldpar (Fig. 4c). Quartzite in the study area is of high elevation and mostly grey in colour. The quartzite is coarse grained with prominent horizontal partings (Fig. 4d) while in some localities, it is fine-grained. Among the different structures on the rocks are veins, fractures, schistosity and veinlets. Among the localities where quartzite occur around Ikogosi are the resort centre, some were also found along the Ipole-Iloro road, Arinta Waterfall area and along its road.

Migmatite gneiss

Migmatite-gneiss is a metamorphic rock with genissic and granitic parts. The migmatie-gneiss contains light coloured (leucocratic) and dark coloured (melanocratic) portions. Migmatite-gneiss in the area is mainly fine-grained and range from grey to dark colored. They occur as rocks with average elevation and are highly vegetated. From field observation, the migmatite-gneiss is composed of quartz, feldspar, biotite and hornblende. The observable structural features are pegmatitic dyke, veins, veinlet, cleavage and fractures. They are found along the Ipole-Iloro road and also close to the Ikogosi-Ilawe boundary.

Fig. 4: (a) Managanese deposit from the undifferentiated sediments, (b) metaconglomerate with visible minerals like quartz, feldspar and micas, (c) quartzite with conspicous feldspar (d) coarse-grained quartzite with horizontal partings.

Microscopic evaluation of rocks in the study area

Thin section petrography revealed that the rock samples in the study area are both coarse and fine in texture. The minerals observed are quartz, feldspar (plagioclase and microcline), hornblende, pyroxene, biotite, muscovite, opaque minerals (iron oxide). Among the mineral assemblage in the schist, quartz is dominant, others are feldspar (plagioclase and microcline), hornblende, biotite and opaque minerals (iron oxide). Microcline occurs as large euhedral crystals with cross hatched twinning, plagioclase occurs with no visible twinning. The biotite content is low in migmatite-gneiss and relatively high in schist and quartzite. Ferromagnesian minerals (hornblende, pyroxene) and opaque mostly iron oxide is also found in the rocks. Quartz is the most abundant mineral, followed by biotite in all the rocks in the study area (Table 1). Quartzite shows predominantly quartz, accessory muscovite and opaque minerals. Muscovite occurs as brightly colored platy minerals (Fig. 5d and Fig. 6a). Ferromagnesian minerals such as hornblende and pyroxene are also present in some of rock samples (Fig. 5c). Quartz occurs as granoblastic and euhedral crystals with well-defined outlines. It exhibits weak birefringence, low relief with wavy extinction, few grains however appear cloudy. Accessory tourmaline occurs in some quartzite samples obtained from mining site in the study area (Fig. 6c).

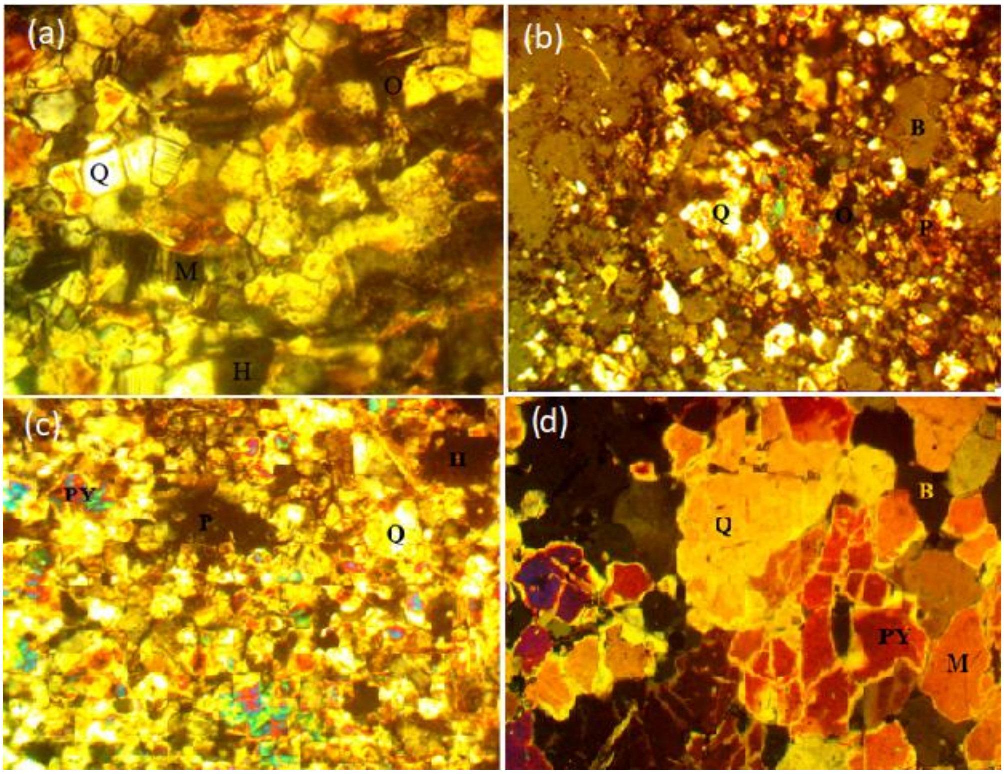

Figure 5; (a) Photomicrograph of manganese bearing pegmatite vein from Erinjiyan Ekiti in transmitted light showing constituent minerals (xpl, mag. x 4), (b) photomicrograph of pegmatite from Erinjiyan Ekiti in transmitted light (xpl, mag. x 4.), (c) photomicrograph of metaconglomerate from Erinjiyan Ekiti in transmitted light (xpl) x 4, (d) photomicrograph of quartzite from Ipole-Iloro in transmitted light showing the constituent minerals (xpl) x 4. [Q (quartz), P (plagioclase), B (biotite), H (hornblende), M (muscovite), O (opaque) iron oxide and PY (pyroxene)]

Table 1: Modal composition of Schist unit in Ikogosi (in volume fractions)

Minerals	M1	M2	M3	M4	Average
Quartz	54	51	48	64	54
Feldspar	18	8	-	10	9
Hornblende	9	-	25	13	12
Pyroxene	19	-	-	-	5
Biotite	-	36	21	-	14
Opaque	-	5	6	13	6
Total	100	100	100	100	100

Quartzite sample from the neighborhood of Ikogosi Warm Spring within the Resort Centre also contain radioactive minerals, such as uraninite, zircon which may be attributed as probably the source of heat within the area (Fig. 6c). Quartz constitutes larger part of the rocks with percentages ranging from 46% to 67% in some samples. The relative percentages of each mineral constituent are displayed in Table 2.

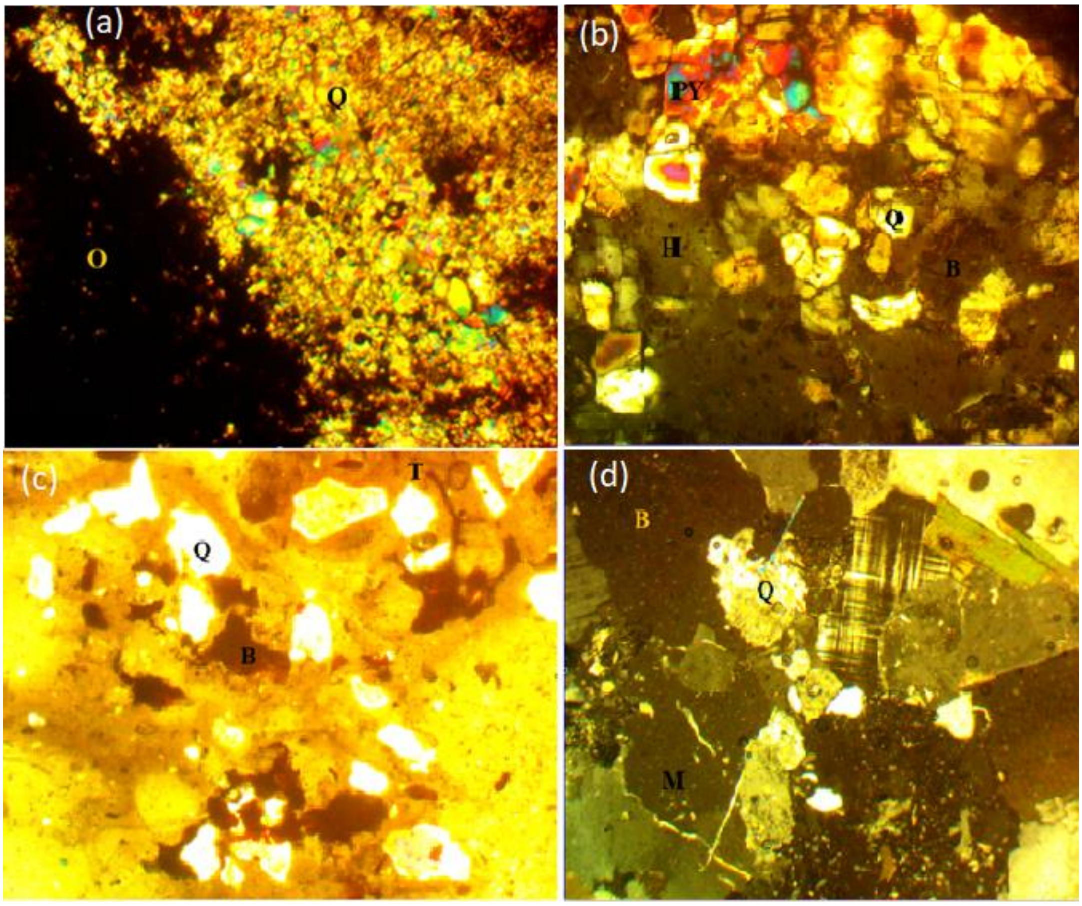

Fig. 6: Photomicrograph of (a) quartzite sample from a stream near the Ikogosi warm stream in transmitted light showing high iron oxide content (xpl) x 4; (b) quartzite sample from Ipole-Iloro in transmitted light showing hornblende as one of its constituents (xpl) x 4, (c) quartzite sample from mining site within the study area in transmitted light showing presence of tourmaline (xpl) x 4. (d) migmatite gneiss from Ipole-Iloro in transmitted light showing constituent minerals (xpl).

Table 2: Modal composition of Quartzite in Ikogosi (values in volume fractions)

Minerals	Q1	Q2	Q3	Q4	Q5	Q6	Average
Quartz	63	52	55	64	67	53	59
Feldspar	23	-	-	-	-	-	4
Hornblende	-	-	9	-	-	27	6
Pyroxene	7	5	18	14	-	-	7
Biotite	-	-	18	9	33	20	13
Muscovite	7	3	-	13	-	-	4
Opaque	-	40	-	-	-	-	7
Total	100	100	100	100	100	100	100

Quartz, feldspars (microcline), hornblende, biotite are the minerals recognized in thin section of the migmatite-gneiss. The feldspars are large well-formed crystals of microcline with crosshatched twinning (Fig. 6d). Pyroxene and muscovite contents are very low. Biotite in the migmatite gneiss is mainly the brown colored type with medium relief. Modal analysis of migmatite-gneiss from the study area (Table 3) revealed average percentage of 57, 14, 11, 10, 6, and 2 for quartz, feldspar, hornblende, biotite, muscovite and pyroxene, respectively.

Table 3: Modal composition of Migmatite-gneiss in Ikogosi (in volume fractions)

Minerals	MG 1	MG 2	MG 3	Average
Quartz	58	57	56	57
Feldspar	18	13	12	14
Hornblende	12	11	10	11
Pyroxene	-	5	-	2
Biotite	10	7	12	10
Muscovite	2	7	10	6
Opaque	-	-	-	0
Total	100	100	100	100

The study area contains quartzite, schist and migmatite-gneiss. Thin section study indicates that the minerals in quartzite are quartz, feldspar, hornblende, pyroxene, biotite, muscovite and opaque mineral. The minerals in the schist are quartz, feldspar, hornblende, pyroxene, biotite, muscovite and opaque while migmatite-gneiss contains quartz, feldspar, biotite, muscovite, pyroxene and hornblende. Furthermore, thin section study reveals that the quartzite consists of both fine and coarse-grained types, the schist is coarse grained while migmatite-gneiss is fine-grained.

Geochemistry

Geochemical analysis of six fresh representative samples of quartzite, three schist samples and one migmatite-gneiss were carried out, thereafter, some variation diagrams were plotted from the geochemical data to establish the origin of rocks in the study area. Elemental composition of the rocks in the study area (Table 4a and 4b) indicates that the schist in Ikogosi contains predominantly SiO_2 (10.12 – 80.69 %; ca. 34.42%), Al_2O_3 (1.12 – 2.86 %; ca. 1.77%), and Fe_2O_3 (13.34 – 83.37%) with an average of 59.42%. This trend though with slight variations, was observed in other rock units as SiO_2 in quartzite ranged from 80.49 – 87.43% with an average of 84.89%, while SiO_2 content in migmatite-gneiss is 58.06%. Al_2O_3 concentrations in quartzite (3.23 – 10.91%) with an average of 5.64%, while Al_2O_3 contents in migmatite-gneiss is 12.57%. High alumina content in quartzite and migmatite-gneiss suggest high concentration of alumino-silicate minerals like feldspar and micas (Ayodele and Ajayi, 2016). Average Fe_2O_3 content in quartzite (3.84%) is less than Fe_2O_3 content (12.33%) in migmatite-gneiss. K_2O content in quartzite (0 – 1.19%) with an average of 0.51% is higher than average (0.06%) in the schist. Absence of MgO in the rocks of the study area may have been precipitated by low concentration or absence of ferromagnesian minerals like amphibole, olivine and serpentine (Ayodele and Ajayi, 2016). The three oxides (SiO_2, Al_2O_3 and Fe_2O_3) constitute about 85 – 90% of the bulk chemical composition of the rock units in the study area. K_2O *vs* SiO_2 variation diagram (Fig. 7a) shows a negative correlation indicating that increasing SiO_2 does not symbolize corresponding higher K_2O. Similarly, SiO_2 *vs* TiO_2 plot (Fig. 7b) shows negative correlation with TiO_2. In the plot of Fe_2O_3 *vs* SiO_2 (Fig. 7c), Fe_2O_3 content in quartzite and migmatite-gneiss is relatively low compared to the content in schist. This negative correlation may imply that the two metamorphic rocks have heterogenous origin. Fe_2O_3 variation in the two rock types may be attributed to variation in the degree of metamorphic remobilization or deuteric activity during magmatic crystallization of the precursor igneous rock (Akinola and Obasi, 2020). CaO and Al_2O_3 plot against SiO_2 (Figs. 7d and 7e) show a negative correlation and a decrease as SiO_2 increases. Previous work (Opara et al. 2014) on petrology and geochemistry of basement rocks in Okom-Ita area, Oban Massif, Southeastern Nigeria revealed SiO_2 content in the range of 60-75%. High SiO_2 values (> 65%) in quartzite from Ikogosi Ekiti may reflect acidic nature of the source rock. General classification of rocks by SiO_2 content indicates 65% silica are felsic, those between 55 and 65% are intermediate, while those between 45 and 55% are mafic and SiO_2 < 45% are ultramafic. Based on this classification, quartzite falls within felsic group of rocks, migmatite-gneiss is intermediate and the schist ultramafic. The plot of K_2O *vs* SiO_2 (Fig. 7a) showed quartzite and schist fell below the calc-alkaline series line indicating that the magma from which they were derived have low alkali contents. Migmatite-gneiss plots within shoshonitic field showing higher alkali content higher than can be accommodated in feldspars. The excess alkalis appear as feldspathoids, sodic pyroxene, sodic amphiboles and other alkali-rich phases. TiO_2 *vs* SiO_2 plot (Fig. 7b) revealed the basement rocks around Ikogosi have igneous affinity; hence, the rocks have igneous origin.

Generally, geochemical analysis revealed SiO_2, Al_2O_3, Fe_2O_3, CaO, K_2O, TiO_2, P_2O_5 as the major oxides, with SiO_2, Al_2O_3, Fe_2O_3 constituting about 85–90% of the chemical composition of the rock units in the study area. Variation diagrams from the data showed negative correlation between SiO_2 and other oxides. Rocks in the study area have preference for igneous origin.

Conclusions

This study revealed quartzite, migmatite gneiss and undifferentiated metasediments as major rock units in the study area. Mineralogically, quartz and feldspar are dominant in most of the rock units. Chemical assessment of the rocks indicates SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, K_2O, TiO_2, P_2O_5 as major oxides. Petrogenetic study of rocks in the study area classified quartzites as felsic, migmatite gneiss as intermediate, while the metasediments fall into the felsic and ultramafic in parts. Variation diagram of

Table 4a: Chemical composition (in mass fractions) of quartzites around Ikogosi.

Oxides	Q1	Q2	Q3	Q4	Q5	Q6	Min	Max	Mean	St. Dev
SiO_2	85.48	87.43	86.49	80.49	85.23	84.2	80.49	87.43	84.89	2.42
K_2O	0	0.01	0.63	1	0.23	1.19	0	1.19	0.51	0.51
Al_2O_3	3.5	3.23	5.03	10.91	5.49	5.66	3.23	10.91	5.64	2.78
CaO	0.04	0.03	0.04	0.05	0.03	0.03	0.03	0.05	0.04	0.01
Fe_2O_3	4.83	4.66	3.12	2.55	4.06	3.79	2.55	4.83	3.84	0.88
MgO	0	0	0	0	0	0	0	0	0	0
TiO_2	0	0	0	0.15	0	0	0	0.15	0.03	0.06
P_2O_5	0.14	0.13	0.2	0.18	0.16	0.2	0.13	0.2	0.17	0.03
SO_3	0.47	0.25	0.49	0.37	0.27	0.35	0.25	0.49	0.37	0.1
V_2O_5	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0
Cr_2O_3	0	0	0	0.01	0.01	0.01	0	0.01	0.01	0.01
MnO	0.07	0.03	0.01	0.02	0	0.02	0	0.07	0.03	0.02
CoO	0.05	0.05	0.04	0.03	0.04	0.03	0.03	0.05	0.04	0.01
NiO	0.08	0.07	0.06	0.06	0.06	0.07	0.06	0.08	0.07	0.01
CuO	0.07	0.05	0.04	0.06	0.05	0.06	0.04	0.07	0.06	0.01
ZnO	0.1	0.08	0.07	0.08	0.09	0.09	0.07	0.1	0.09	0.01
PbO_2	0.01	0.02	0.01	0	0.01	0.01	0	0.02	0.01	0.01
WO_3	0	0.09	0.06	0	0.06	0.01	0	0.09	0.04	0.04
Au_2O	0	0.04	0	0	0	0	0	0.04	0.01	0.02
Ag_2O	0.01	0	0	0.01	0	0	0	0.01	0	0.01
Nb_2O_5	0	0	0.02	0.03	0	0.01	0	0.03	0.01	0.01
MoO_3	0.27	0.15	0.19	0.27	0.27	0.16	0.15	0.27	0.22	0.06
SnO_2	2.59	1.94	1.88	1.92	2.08	2.26	1.88	2.59	2.11	0.27
Sb_2O_3	2.27	1.75	1.6	1.79	1.83	1.8	1.6	2.27	1.84	0.23
Total	99.99	100.0	99.99	99.99	99.98	99.97				

Table 4b: Chemical composition of metasediments and migmatite gneiss around Ikogosi.

Oxides	M. Gneiss	Metasediments			Min	Max	Mean	Std. Dev
Rx. type	Migmatite	schist	Schist	Schist				
SiO_2	58.06	80.69	12.46	10.12	10.12	80.69	34.42	40.09
K2O	8.61	0.04	0.08	0.06	0.04	0.08	0.06	0.02
Al_2O_3	12.57	2.86	1.34	1.12	1.12	2.86	1.77	0.95
CaO	0.34	0.04	0.07	0.08	0.04	0.08	0.06	0.02
Fe_2O_3	12.33	13.34	81.56	83.37	13.34	83.37	59.42	39.92
MgO	0	0	0	0	0	0	0.00	0.00
TiO_2	0.41	0	0.04	0	0	0.04	0.01	0.02
P_2O_5	0.37	0.21	0.52	0.45	0.21	0.52	0.39	0.16
SO_3	0.38	0.38	0.06	0.05	0.05	0.38	0.16	0.19
V_2O_5	0.02	0.01	0.01	0.03	0.01	0.03	0.02	0.01
Cr_2O_3	0.01	0.01	0.07	0.07	0.01	0.07	0.05	0.03
MnO	0.05	0.03	0.42	1.9	0.03	1.9	0.78	0.99
CoO	0.24	0.33	2.26	1.88	0.33	2.26	1.49	1.02
NiO	0.12	0.04	0.02	0.02	0.02	0.04	0.03	0.01
CuO	0.1	0.02	0.01	0.01	0.01	0.02	0.01	0.01
ZnO	0.17	0.07	0.05	0.05	0.05	0.07	0.06	0.01
PbO_2	0	0	0.05	0.06	0	0.06	0.04	0.03
WO_3	0.01	0.08	0	0.01	0	0.08	0.03	0.04
Au_2O	0	0	0.04	0	0	0.04	0.01	0.02
MoO_3	0.42	0.2	0.32	0.14	0.14	0.32	0.22	0.09
SnO_2	3.03	0.86	0.33	0.29	0.29	0.86	0.49	0.32
Sb_2O_3	2.63	0.77	0.28	0.29	0.28	0.77	0.45	0.28
Total	99.87	99.98	99.99	100				

K_2O *vs* SiO_2 revealed that quartzites and metasediments are tholeiitic (low calc-alkaline), while the migmatite gneiss are shoshonitic. TiO_2 *vs* SiO_2 plot shows the rocks in the study area.is of igneous origin.

List of Abbreviations

1) ED – XRF – Energy Dispersive X – Ray
2) Fig. – Figure
3) Q – Quartz, P – Plagioclase, B – Biotite, H – Hornblende, M – Muscovite, O – Opague (Iron Oxide)., PY – Pyroxene.
4) MG – Migmatite, Q1 – Q6 – Quartzite

Declarations

Availability of data and materials: All data generated or analysed during this study are included in this published article

Competing interests: The authors declare that they have no competing interests" in this section.

Funding: *Funding was from contributions by Authors*

Authors' contributions: All Authors participated in the field work and write up of the project. AO designed the project and as a group Leader ensure prompt completeness of the research. AO serves as the corresponding author to this research. SO was responsible for supervising the Laboratory work. OO plotted and interpreted most of the graphs while LO edited the write up.

Acknowledgements: *Not applicable*

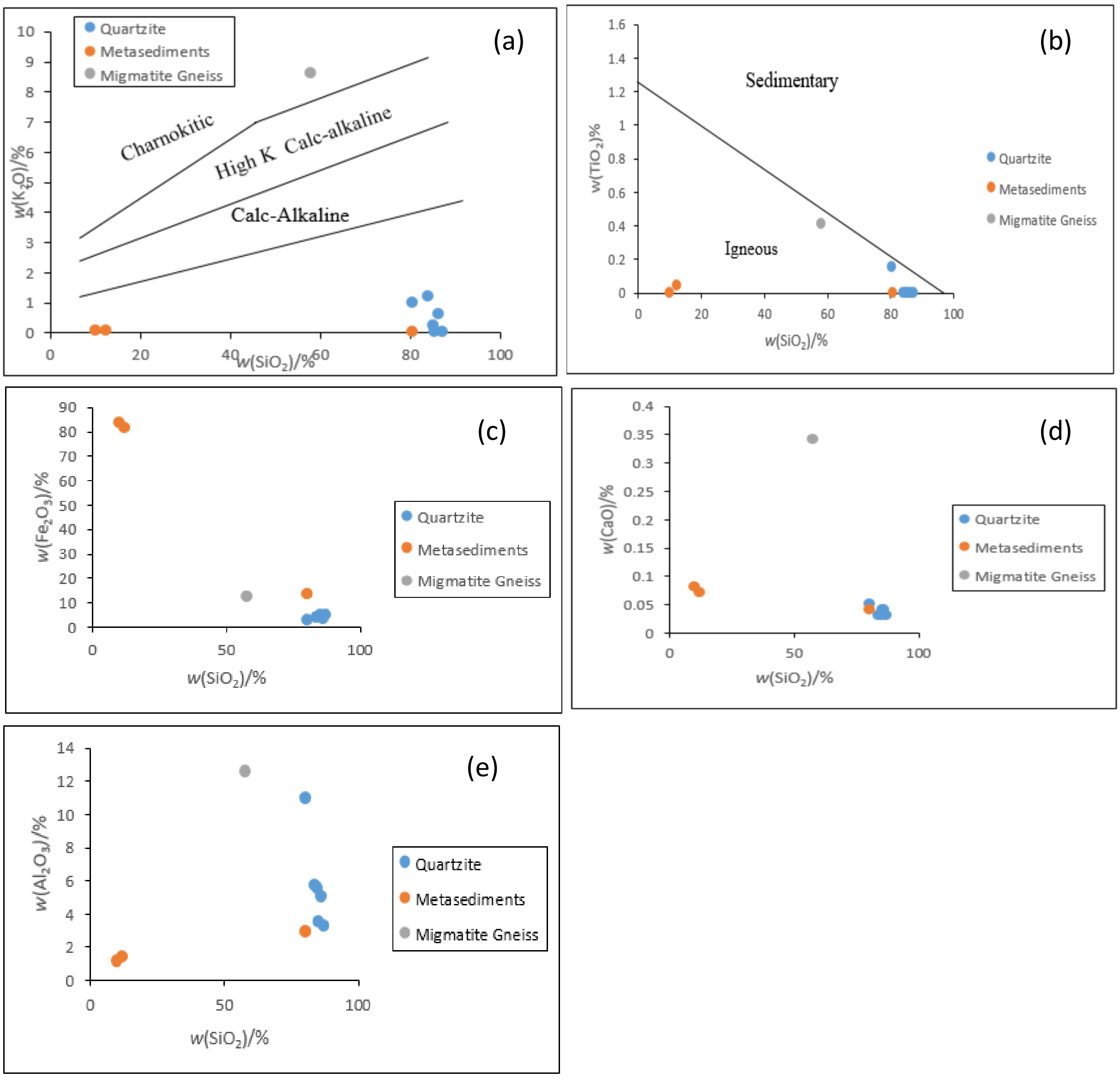

Fig. 7: Harker diagram showing the plot of (a) K_2O *vs* SiO_2 indicating low calc-alkaline and charnokitic series of the rock units (after Peccerillo and Taylor, 1976) (b) TiO_2 *vs* SiO_2 indicating igneous origin of the rock units (after Tarney, 1977), (c) Fe_2O_3 *vs* SiO_2, high concentration of Fe_2O_3 in some metasediments might possibly indicate presence of an ore, (d) CaO *vs* SiO_2, (e) Al_2O_3 *vs* SiO_2.

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