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Preliminary Study of the Geology and Structural Trends of Lower Proterozoic Basement Rocks in Ogbomoso, SW Nigeria

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Abstract
The rock distribution of Ogbomoso Town studied and mapped revealed that the study area has five rock types. The study area shows that the terrain is underlain by a migmatite – gneiss - quartzite complex. The relationship suggests an evolved granitic melt from a migmatite with a metasediment precursor. The rocks are generally low lying except for the porphyritic granite gneiss that shares the same relief with rocks at Oyo town. Outcrops encountered were studied for their mineralogical and structural characteristics. Twelve hand specimen samples for all rock type as well as four thin section slides cut for the granite and Porphyroclastic gneisses show the presence of quartz, potash feldspar, plagioclase, biotite and muscovite (especially from quartzofeldsparthic veins) as the main mineral phases. A high amphibolites facies is implied. Myrmekite, dissolution rim texture and vein anti-perthite were observed from thin section slides while the gneissose rocks generally reveal a range in fabric from idiomorphic to hyp-idiomorphic grains that are medium to coarse in size.The structural pattern from remotely sensed images was quite revealing as faults that were not conspicuous in the field probably due to vegetation were inferred. Lineaments trace which appear generally as curvilinear reveal sinistral NE/SW trend wrench fault. Measurements taken for the joints observed in the field describe a bimodal set. Two joint sets that trend NE/SW and NW/SE were observed to intersect at c. 60^0. The terrain which does not appear to be highly jointed is suspected to be faulted at the southern and north eastern parts of the town.
Key words: Migmatite-gneiss, granitization, myrmekite, crenulation and lineament)

Introduction
Ogbomoso town lies within 4°10´E - 4°20´E longitude and 8°00´N - 8°15´N latitude (Fig. 1). The geology of this area has only been sparsely reported. However some work has been done in recent past on the hydrogeophysics and hydrogeochemistry of the area (Adabanija, et. al., 2002). The study area lies within the Southwestern area of Nigeria which is underlain by the Basement Complex. This area is expected to be composed of rocks within the first group of classification as described by Rahaman (1976). The description of some of the rocks that underlie this area have been described, rather succinctly, by the Geological Survey of Nigeria (now referred to as Nigerian Geological Survey Agency, NGSA) (Oluyide, et al., 1998). Also, there has not been any dedicated report on the geology of this area.
Very little is known about its geological setting, in relation to petro-structural, petro-chemical, petrological and geo-chronological studies. This study reports the geological and structural setting of Ogbomoso town and its immediate environ. The rock setting within Ogbomoso town is a relatively simple setting in terms of rock suit; however the structural elements reveal more complex events that occurred in the Archean to lower Proterozoic. Basically four type rocks characterize the area and are i) the ubiquitous Granite gneiss, ii) the undifferentiated Migmatite gneiss, iii) Porphyroclastic gneiss and iv) the centrally emplaced Quartzites.
The structural features from land and satellite view is quite revealing. Strike slip faults were observed from the ground field work while several strike slip and curvi-linear lineaments were traced out from satellite images obtained and are represented as conjugate lineaments. Structures observed from ground survey were compared to that presented by a DEM image obtained (Map Mart™). A map of the area was drawn showing the geology and structural elements. Samples obtained from two type rocks were cut for petrographical analysis. From these, thin section slides were cut and textural properties were analysed.

The Geological Setting
Ogbomoso town lies on the basement complex of southwestern Nigeria. This terrain has been described by few workers (Adabanija, et al., 2002; Rahaman, 1976; Oluyide, et al., 1998 and Akinloye, et al., 2002). Also, (Goodwin, 1996) describes the geologic evolution of the Benin-Nigeria shield as one not well known. While others have described the geology only generally, the work of (Oluyide, et al., 1998) however seems to be the only reference that describes the geology of the study area with some emphasis. With this approach this work hopes to serve as a further reference to (Oluyide, et al., 1998), which described the geology of Ogbomoso as a

subset of Ilorin. In this work the emphasis is solely to describe the rock distribution as well as their characteristics within Ogbomoso.
The geology of the study area is one that best suits the first classification of (Rahaman, 1976), that is, the Migmatite-gneiss quartzite complex as the rocks within this area consist of Migmatite-gneiss – Banded gneiss, Porhyroblastic biotite-gneiss, Granite and the Quartzite.

Migmatite-gneiss – Banded gneiss Complex.
Field observations reveal that the migmatite gneiss is the most wide spread rock type within the area. It is observed to cover about half the areal extent under this study. The outcrop appears as low lying flat terrains. They occur as dark coloured (mesocratic) massive rocks with streaks of felsic bands that reflect anatexis and are usually covered by a thin sheet of vegetation. This rock group is believed to have formed at ca 2.5 Ga (Rahaman. 1988; Rahaman, et al., 1984) while migmatization of these paleoproterozoic rocks occurred at ca 600 Ma (Pan-African orogeny) during the oblique collision of the Nigerian shield with the West African Craton, basement, followed by anatectic doming and wrench faulting (Kroner and Stern, 2005). This rock type together with granitoids, amphibolites, metasedimenary schist and gneisses, pyroxenites, metagabbros and charnockites dominate the eastern half of the suture line that runs southward from western Hoggar of the Tuareg shield to the gulf of Benin where the study area lies. (Fig. 2) (Goodwin, 1996; Kroner and Stern, 2005).
Field observation (Plates 1a, b, c, and d) reveal different grades of mixing. A high degree of anatexis is displayed in Plate 1a where leucosomes of granitic composition show a very weak lineation. This weak lineation is seen displayed as irregularly convoluted bands, ptygmatitic folds as well as isoclinal to tight-closed folding. In some parts, pods of leucosomes are seen. At Ileaso after Odoje rivers (N 08° 02.621′ and E 004° 17.104′) a leucosome pod 5.3cm wide and 31cm long is observed (Plate 1d). Hand specimens reveal the presence of quartz, feldspar, biotite and hornblende. The mineralogy suggests a high amphibolites facies type. The migmatitic gneiss of ogbomoso can be described on structural terms after (Mehnert, 1968) as Phlebitic migmatite towards the granite (Plate 1a), Stromatic especially as a boundary around the quartzite-quartz schist (Plate 1c) while in the middle or core the rock appear more of Podiform migmatite (Plate 1d).
The origin of the Migmatitic gneiss of Ogbomoso is yet to be reported in relation to the granite occurrence within its vicinity. Field evidences suggest that the degree of migmatization, although only vaguely, is one of metasomatic segregation. Based on the relation of the leucosomes with the melanosomes and also with an absence of mesosomes to a large extent, the authors propose, at a first approximation, processes of formation of this migmatitic gneiss as one of internal subsolidous migmatization of metamorphic differentiation rather than internal igneous migmatization (anatexis) (Yardley, 1978). Although there is the presence of granite body that may pass for a migmatitic granitoid considering the size and orientation of its pervasive quartzo-feldspathic veins (Plate 3). That this neighbouring granite body is of igneous origin or that of metamorphic is yet to be investigated. However the granite body does show that quartzo-feldspathic veins that describe migmatization within the migmatite gneiss body is equally present and pervade it. These quartzo-feldspathic intrusions may be hydrothermal in origin and may impose metasomatic alterations in these rocks. It was observed that parts of the migmatite gneiss body close to contacts, especially at quartzite/migmatite contacts, circular to curvi-linear bands of leucocratic rock bands become more prominent (Plate 1c). Swirling felsic bands characterize portions of migmatites. Around Arowomole, the vertical section of an outcrop observed shows relict banding, S_0 (Plate 1f). This evidence suggests a probable sedimentary protolith that experienced migmatization and probably, eventually granitization to birth the migmatite gneiss and the granite.

Granite
The granite body is a low lying massive stock with gentle elevations. The granite's slope presents a gentle inclination that ascent is not noticed except at road cuts or places where exfoliation has created a steep slope. Field evidence show that this body is not a homogeneous granite body but that only certain portions appear granitic in texture as evident by lack of schistocity while most parts show gneissose texture (Plate 2). Also, quartzo-feldspathic veins appear to thoroughly run through this rock body in almost all directions but most prominently in the horizontal and vertical directions (Plate 3). It is proposed that this granite body is the product of a metamorphic process, metasomatism, rather than magmatic processes (anatexis).
The mineralogical composition is made up of quartz, feldspars (alkaline feldspar) biotite and probable amphiboles. The minerals are medium size to coarse grains from hand specimens. They range in size from a 0.2cm to 8cm. Thin-section slides reveal subhedral to anhedral grains of quartz, large biotite laths as well as plagioclase. The presence of alkaline feldspar is not depicted in the photomicrographs shown here, however myrmekitic texture suggests their presence. Photomicrographs reveal perthites and myrmekites (Plates 4 i, ii a and ii b). The perthite is single grained that can be interpreted to have formed initially at a high temperature under dry low pH_2O (a probable hypersolvus granite). With decrease in temperature the sinlge perthite forms.

This evidence of low H_2O pressure indicates a process of migmatization as that eventually culminated into granitization (McBirney, 1993). The myrmekite observed suggest a localized metasomatism (Williams, et. al., 1982). The granite was quarried during the road construction sub-base.

Porphyroclastic gneiss

The Porphyroclastic gneiss is spatially located at the northwestern end of Ogbomoso town towards Ikoyi. The rock is believed to underly the water dam at the northwestern end of the geological map (Fig 1). This body outcrop as hills with minimal elevation above the general terrain. It has been described that the African continent is composed predominantly of plains and plateau and intervening escarpments as a result of erosion while outcrops with steep slopes are common around areas of large volcanoes or doming and major rifting (Wright, et al., 1985). The Porphyroclastic gneiss hills are perhaps results of doming from epeirogenic movements of uplift, subsidence and faulting that so characterize the Phanerozoic times (Wright, et al., 1985). Outcrops exhibit phenocrysts of alkali feldspar laths that show rotation as a result of shearing (Plate 5a). Other minerals observed correspond to the simple mineralogy expressed by the granite gneiss and these include quartz, feldspars and biotite. The feldspar grains are the most conspicuous and range in size from 1cm to 5.5cm long. These feldspar laths posses an average width of 2.3cm.

An outcrop located adjacent the turning to the water dam on the road to Ikoyi – Igbetti reveals evidence of S_2 schistocity as a result of crenulation. This implies a D_2 deformation episode and invariably M_2 metamorphism. Also other features charactering the rock include melanocratic xenotlith and granophyric veins (Plate 5b). Thin section reveals the presence of hornblende having inclusions.

Quartzite/Quartz schist

The metasedimentary rock unit has been classified into two groups namely the: i) Older metasediments and ii) the Younger metasediments) Wright, et al., 1985). This classification is similar to that given to the granite intrusions of Nigeria (i. e.) the Older granites and ii) the Younger granites). The Older meta-sediments were reported to occur as intercalated rock units among the gneisses and migmatites. To this class belongs the quartzite/quartz schist of Ogbomoso town. This rock type occurs among the migmatite-gneiss complex within the study area (Fig 4). Field observations show that they lack the presence of intense folding as is characteristic of the Younger meta-sediments.

The presence of Sillimanite and Kyanite have not been established as at press time as presence of these minerals further help to differentiate the Younger metasediments from the Older metasediments. The authors' conclusion that the Ogbomoso quartzite/quartz rock unit belong to the Older meta-sediment therefore, is based on mode of occurrence solely. The quartzite/quartz schist outcrops as a hill at the High School, Arowomole and grades into a peneplain towards the old Ogbomoso – Odo Oba – Oyo road. Schistocity (S_0) is observed and this defines the dip of the rock (Plate 7a and b). The outcrop spans from Randa – Baptist seminary through Taki, Sabo, Oke Alapata, High school area and some parts of the Forest reserve. A NE/SW trend was noted while dip directions show that the hill is antiformal (Fig. 1). Quartz and muscovite appear as the dominant minerals from hand specimen.

Pegmatitic veins

The pegmatitic bodies within Ogbomoso town outcrop as veins that intrude and run the granite gneiss body in a NE/SW trend. They are tabular bodies that host microcline, quartz and muscovite. These pegmatitic bodies were observed to serve as host to disseminated iron ore body that appears as products of magmatic segregation processes (liquation). A sizeable amount of suspected tantalite was observed at the south eastern part of the town towards Oko (N 07^0 59.520′ E 004^0 9.067′). Within the migmatite gneiss complex these veins traverse the host rock crosscutting in a manner that make portions of the host appear as a leptynite. They vary in size from veinlets of a few mm wide to several metres but rarely reaching 100m. These bodies within the granite body, vertical section from RCC quarry, dip east while a few ones but of larger dimension run up and down.

Structures

The Older rocks of Nigeria, to which belong the rocks of Ogbomoso town, have been reported to have suffered heterogeneous deformation as evident by shears of differing degrees, granitization, migmatization and intrusion of large volumes of granitoids (Dada, 2006). Foliation, lineation and schistocity give a dominant general trend of N/S and NE/SW (Fig. 1). This is consistent with the regional trend ascribed to the Benin – Nigeria Shield (Goodwin, 1996). The rocks though sparsely jointed, except for the quartz/quartzite schist unit where it is most pronounced, generally show two joint sets trending NW/SE and NE/SW with the NW/SE being the more prominent (Fig. 5a). Foliation as described by platy minerals (biotite) is weak in the migmatite and granite gneisses while it is most prominent within the semi-banded rim of the migmatite body. The mineral lineation shows a NE/SW trend (Fig. 5b).

From a DEM (Digital Elevation Model) (Fig. 3) obtained for the study area, faults lines are obvious structural elements. From the image, lineament line A-B is seen to run from the southern end of the map in a N/S manner then at some hundreds of meters northwards it trends NW. Other inferred fault lines have been traced (Fig. 4) and it is shown that the fault lines are located essentially at the southern and northeastern parts of the study area. This observation is also corroborated by evidence from google[TM] satellite image obtained for the study area (Plate 8). Many of these lineament lines trend NE/SW while a few trend N/S and yet a few still trend NW/SE.

Summary and Conclusion

The rocks that underlie the study area belong to the Migmatite-gneiss quartzite complex class of Rahaman's (1976) classification. The rocks are crystalline and host high-amphibolite facies mineralogy. The migmatite – gneiss and the granite gneiss rock relationship suggest a granitization process for the evolution of the granite gneiss type rock. The migmatite-gneiss is bounded around the quartz/quartzite schist unit by a thin rim of semi-banded gneiss. It is observed that palingenesis reduced in intensity away from the regions of the migmatite gneiss, close to the granite body, towards the quartzite/quartz schist body.

The Porphyroclastic gneissic rock body show crenulation and imply a S_1 and S_2 schistocity that connotes two deformational episodes D_1 and D_2 as well as two episodes of metamorphism, M_1 and M_2. The formation of the gneissose rock bodies is believed to have resulted from D_1 deformational episode while the crenulation is as a result of D_2 deformationl episode. The field relationship between the granite gneiss and the migmatite-gneiss/semi banded gneiss shows gradational boundaries rather than sharp boundaries that characterize plutonic intrusions (so characteristic of granite bodies) and therefore suggests that these two rocks are cogenetic. The activity of migmatization is proposed to have metamorphosed the metasediment during the granitic intrusion of pan-African orogeny.

The metasediment is observed to be dipping NW and SE and therefore describing an antiformal ridge of steep slopes towards the SE and a gentle slope towards the NW of the rock body. This conforms as the product of the oblique NW-SE compression forces that acted on the Benin-Nigeria shield during the wielding of West African craton to the Congo craton. The dextral faults jointly tend to trend in a NE-SW manner while the sinistral faults, jointly too, appear to trend N-S.

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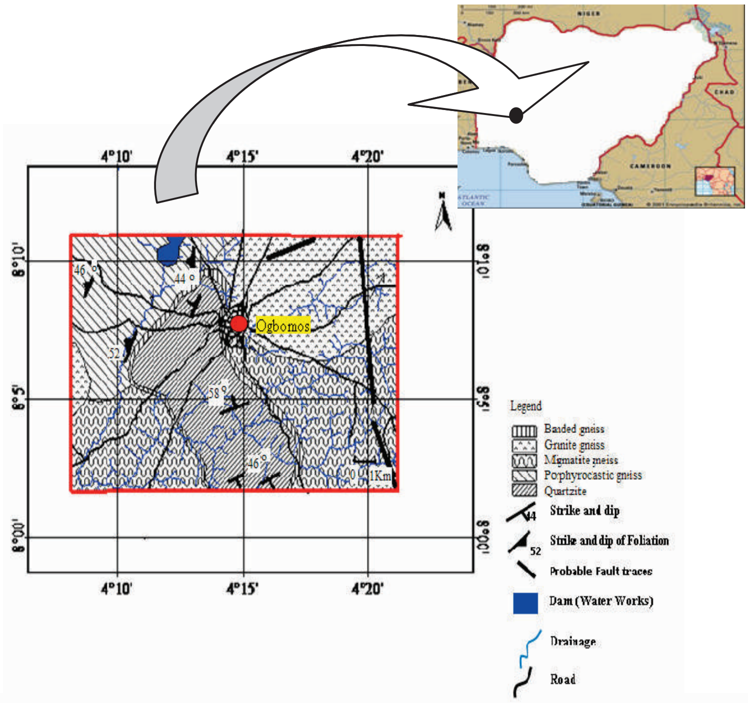


Figure

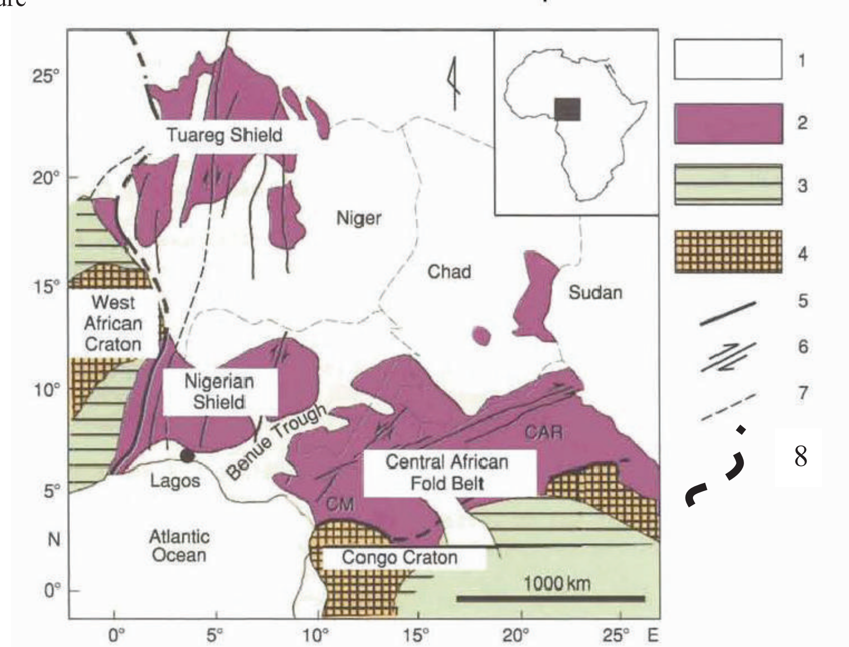


Figure 2: A Sketch map showing Pan-African dornalns in West central Africa. 1, Post-Pan-African Cover; 2, Pan-African domains; 3, pre-Mesozoic platforrn deposits; 4, Archaean to Palaeoproterozoic cratons; 5, craton lirnits; 6, major strlke-slip faults; 7, stateboundaries, 8, suture line. CAR, Central African Republic; CM, Cameroun. (Adapted after Kroner A. et. al., 2005)

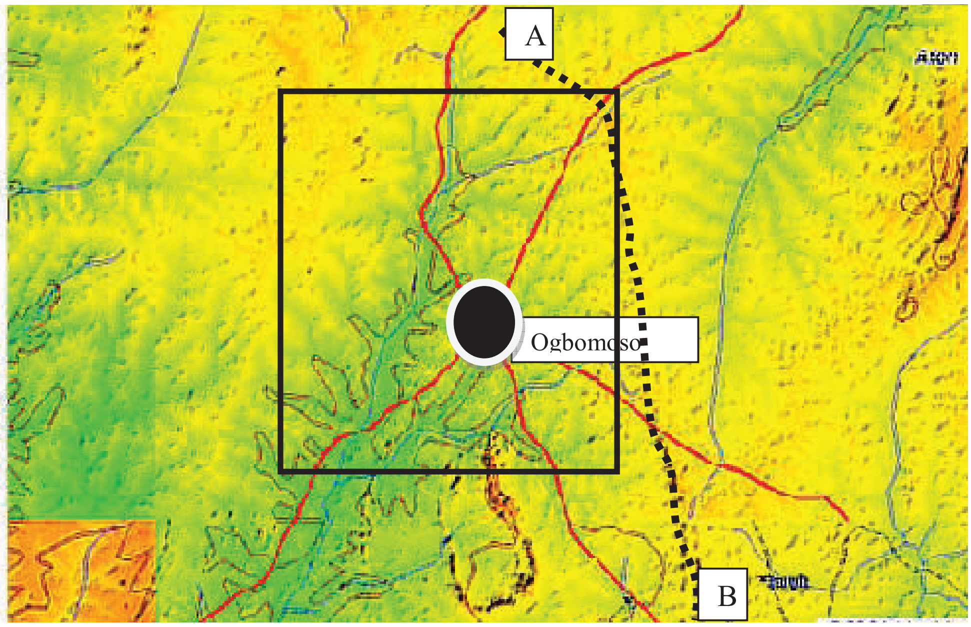


Figure 3: DEM image of the study area. Inset is the study area. (Image from Mart Map™).

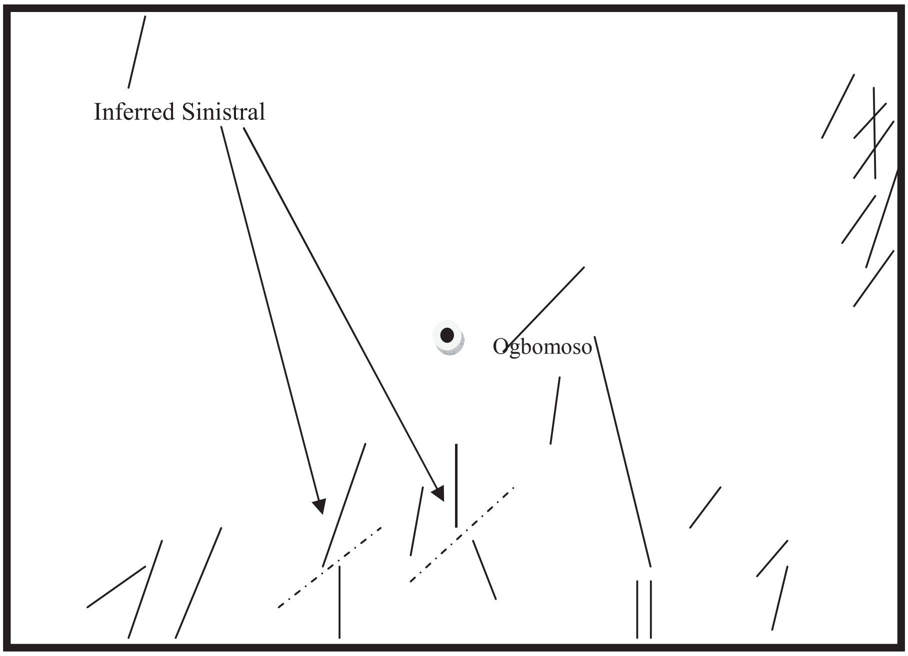


Figure 4: Structural Lineament traced from DEM image of the study area.

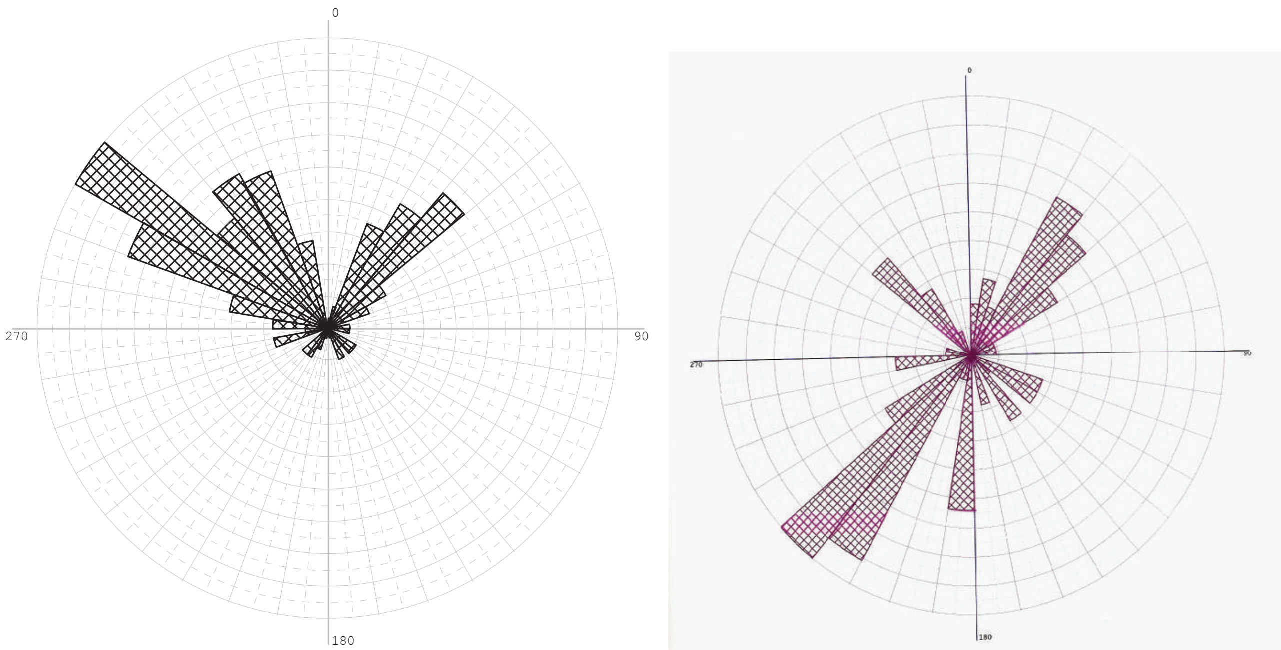
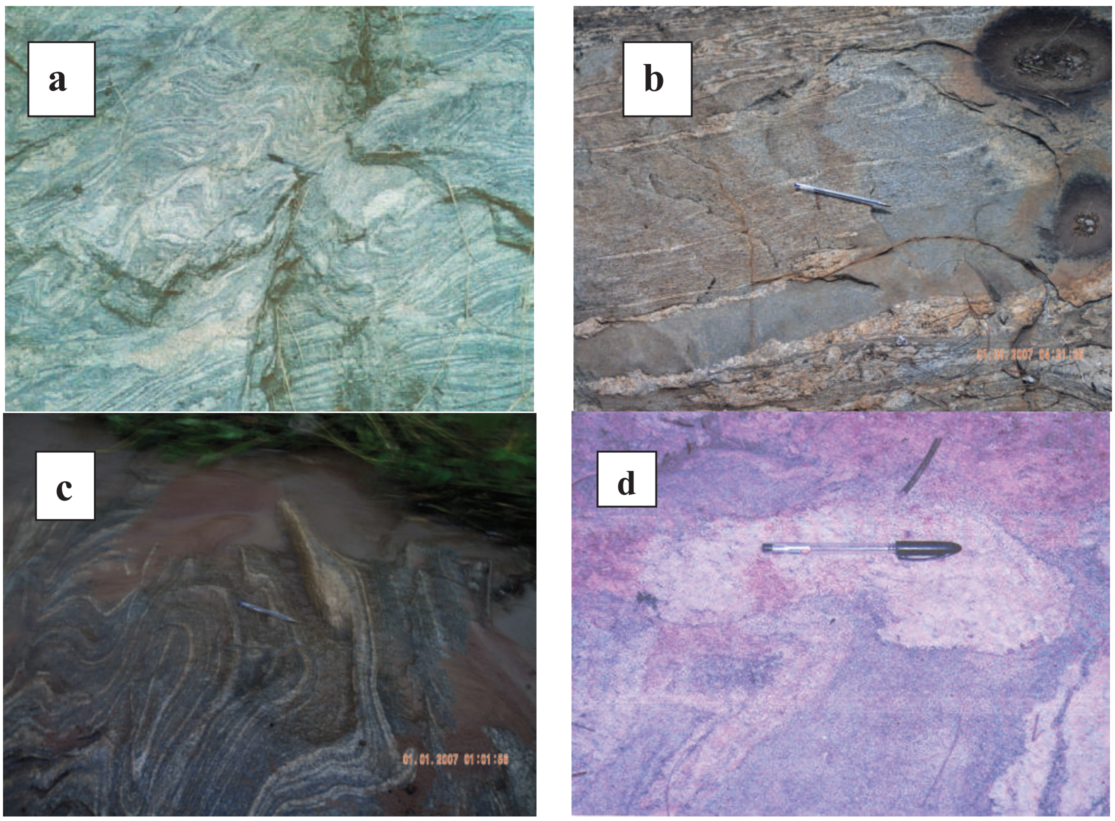


Figure 5: a) Rose diagrams depicting a bimodal trend for the joints in the study area. b) Diagram of mineral lineation of foliated rocks within the study area shows a NE/SW trend.



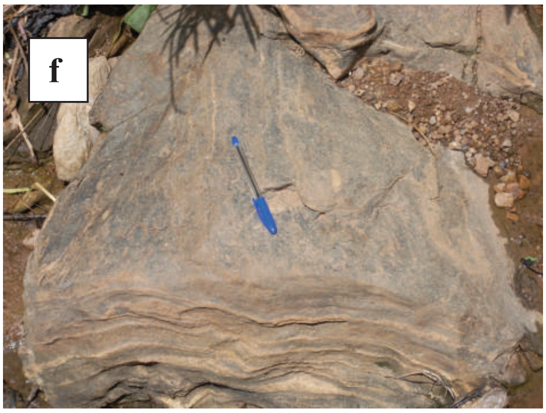


Plate 6: (a) Migmatite gneiss displaying migmatization. Irregular dimensions of leucosomes and ptygmatitic folds of granitic origin are evident. (b) Grey foliated biotite gneiss with evidence of migmatization. Also, concordant Felsic bands appear injected into a more mafic host. This describes the term Venites. (c) Semi-banded Migmatitic gneiss. Felsic bands are concordant and to a large extent an alternation of felsic and mafic bands, though not well defined, are perceived. (d) Foot-like Pod of leucosome of medium size grains that lacks the characteristic of a typical quartzo-feldspatic vein. This does not suggest deep burial migmatization. (e) Tight folding suggests shearing and compression during the pan-African orogeny. Semi banded gneiss as observed at contact of rock with the metasediment suggest that the protolith of the migmatite may be sedimentary in nature. (Cover end of biro displays north as well as scale).

Plate 2: Granite body seen along the RCC newly constructed Ogbomoso – Ilorin road. Stippled thick line demarcates the gneissose texture part to the left while to the right is the granitic texture as evidenced by lack of schistocity. Biro end shows north direction.

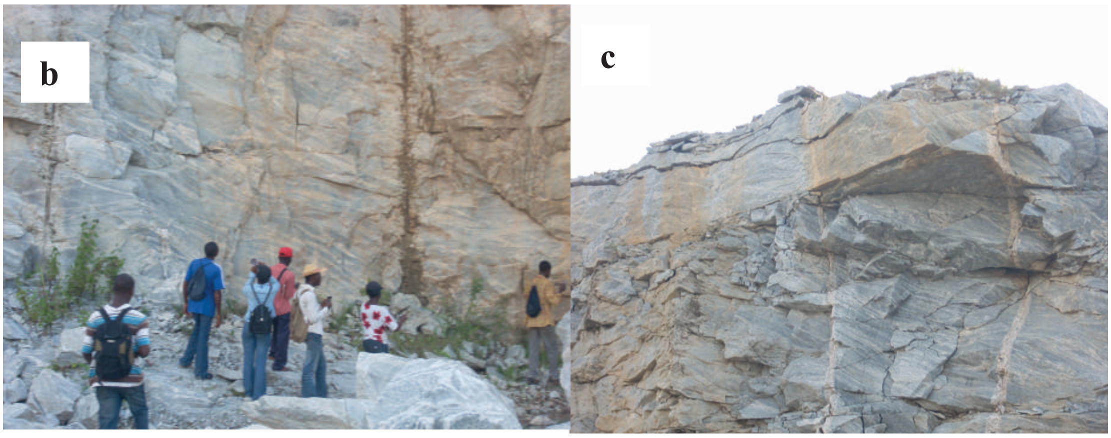
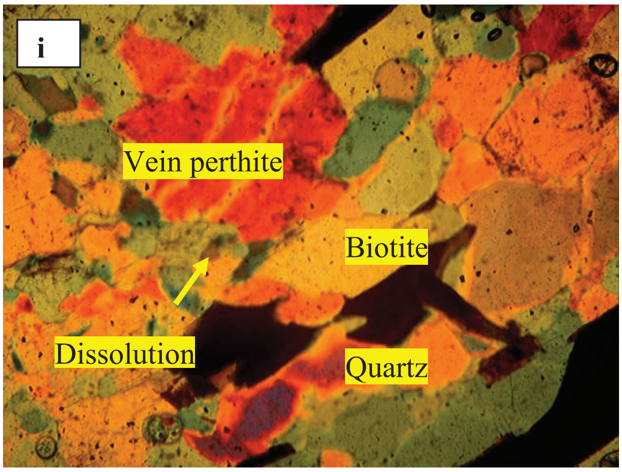
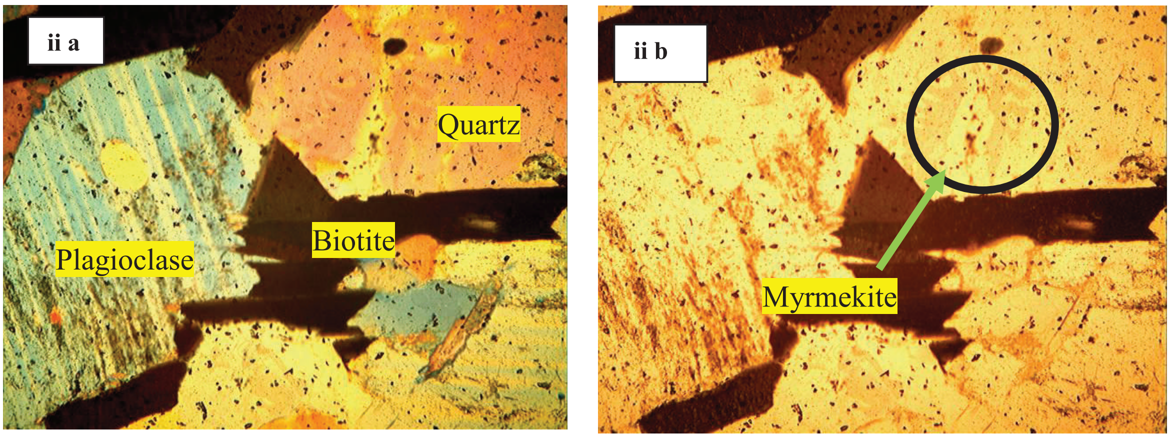


Plate 3: (a) Inclined veins of felsic composition (b) Pervasive pegmatitic veins run through the granite gneiss rock. These veins run both vertically and near horizontally.



Under cross nicol (x40)



Under cross nicol (x40) Under plane polarized (x40)

Plate 4: Photomicrographs of euhedral quartz (Plate i), interstitial vermicular quartz, plagioclase, and biotite (Plate ii a). Single vein perthite is observed in plane polarized light (Plate i) that suggest anhydrous conditions of formation. Myrmekite texture reveals evidence of a localized metasomatism.

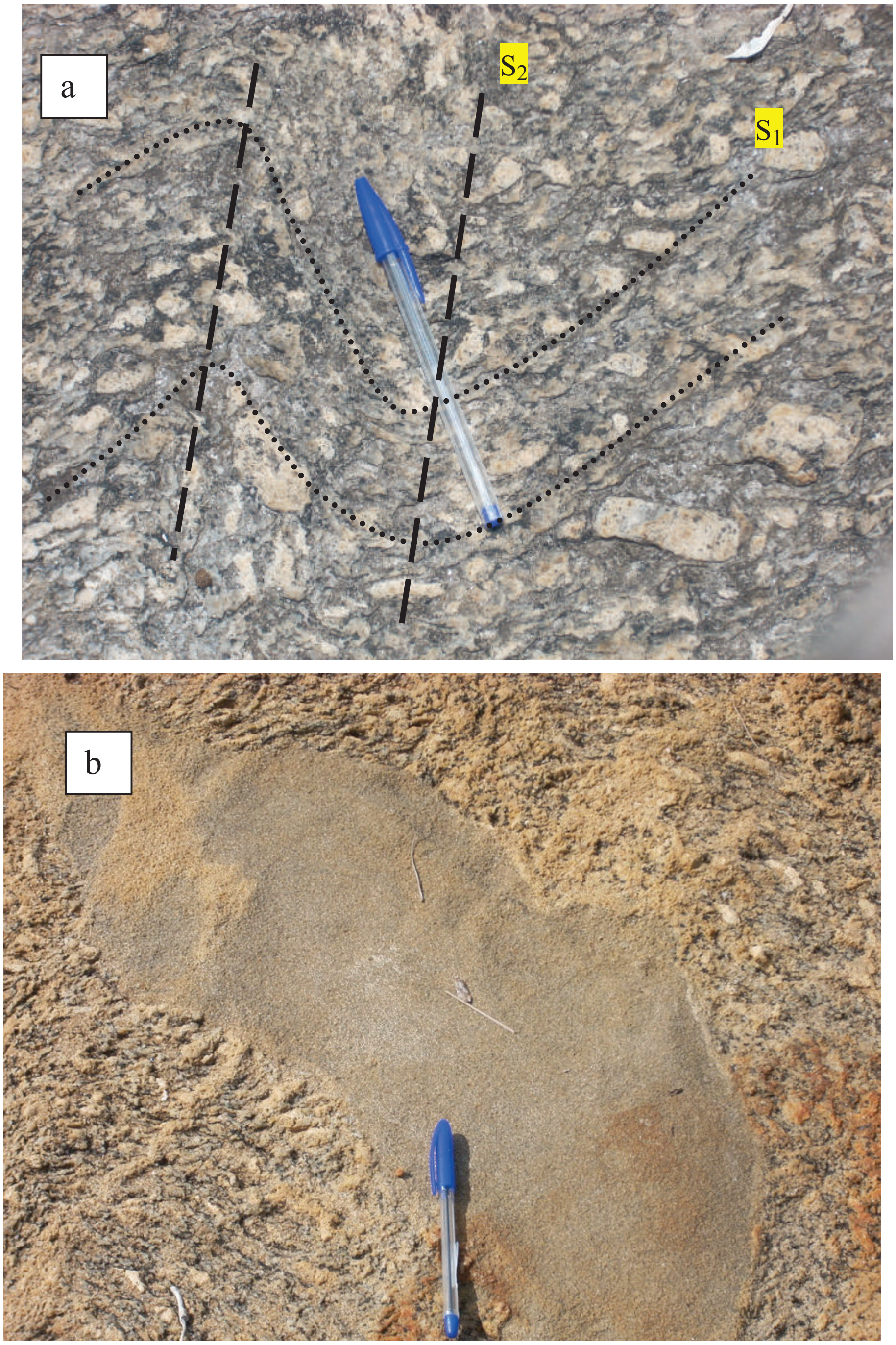
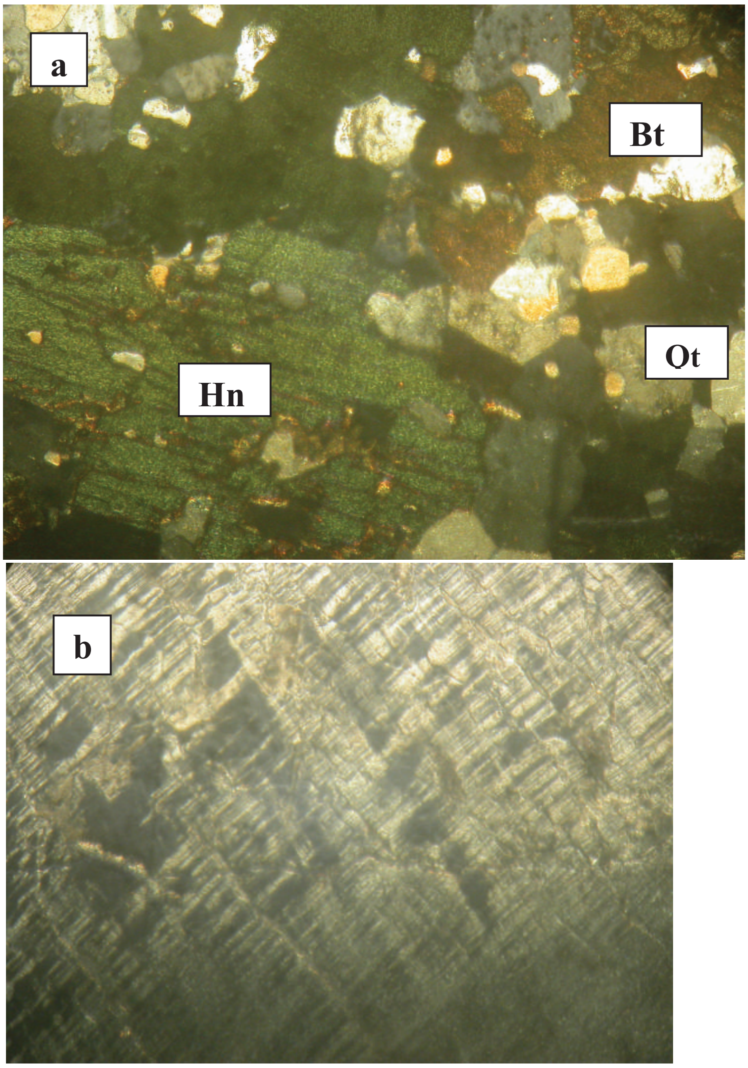


Plate 5: Porphyroclastic gneiss (a) displays alkaline feldspar laths of random orientation. The biro position indicates evidence of shearing as well as rotation of feldspar laths. Relics of deformational episodes are revealed (S_1 and S_2) and inferred (D_1, D_2, M_1 and M_2). (b) Shows a granophyric vein.



X 40

Plate 6: Photomicrographs of Porphyroclastic gneiss display (a) the presence of Hornblende (Hn), Biotite (Bt) and Quartz (Qtz) (b) Microcline crystal showing tartan twinning.

Plate 7: Quartzite/Quartz schist, (a) displays the S_0 schistocity. Also indicated are quartz schist layers of thickness between 2cm – 6cm. (b) illustrates an eastward dipping direction for the bedding planes.

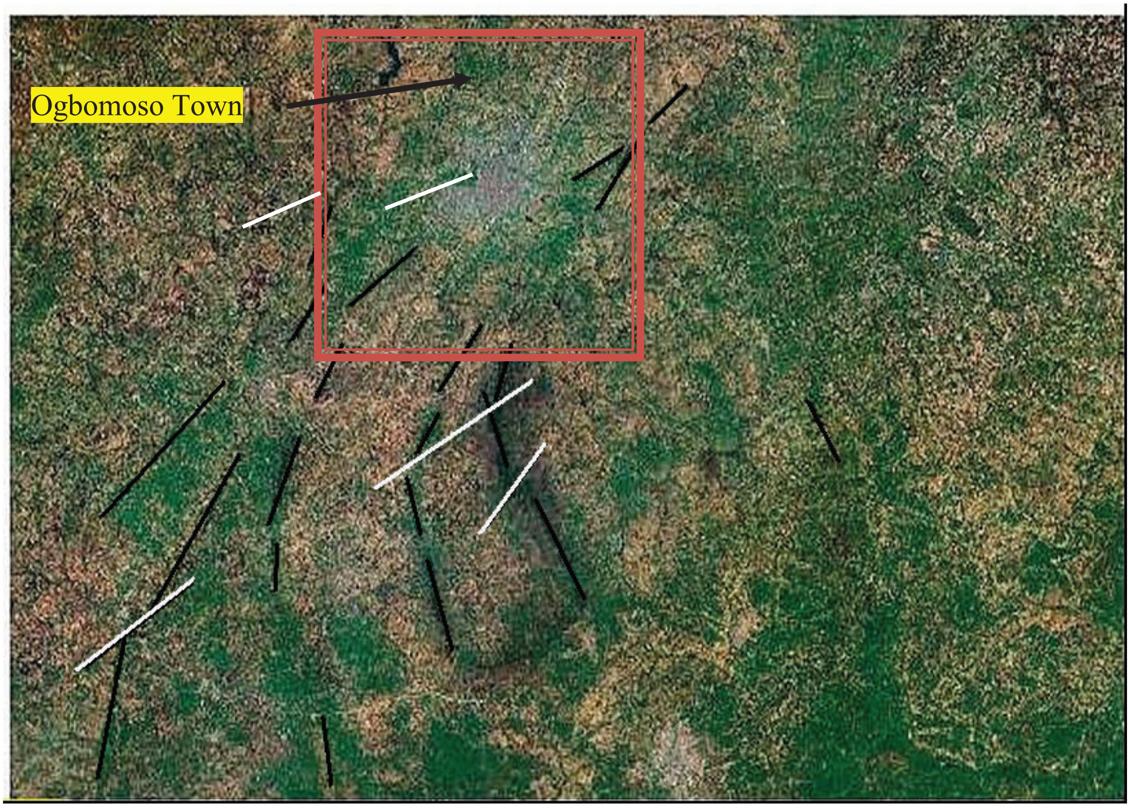


Plate 8: Structural Lineament from satellite image. (Image from google™, 2009). Inset in red boundary is the study area that was ground truthed. It is observed that the inferred faults are curvilinear in nature (black lines) and are localized at the southern and northeastern parts of ogbomoso and its environs. Also, it is inferred that there are evidences of strike slip faults within the area and have been marked as white lines.

References

Adabanija, M. A., Sunmonu, L. A. and Olayinka, A., I. 2002. Integrated Geochemical and Electrical Resistivity Techniques in the Investigation of Corrosive Characteristics of Ground Water in a Low Latitude Crystalline Basement. Science Focus Vol. 1. 6 – 15 pp.

Rahaman, M. A., 1976. Review of the Basement Complex of Southwestern Nigeria. In C. A. Kogbe (ed) Geology of Nigeria. Elizabeth Publishing Co. Lagos. 41 – 58 pp.

Oluyide, P. O., Nwajide, C. S. and Oni A. O., 1998. The Geology of the Ilorin Area. Ministry of Solid Minerals Development, Geological Survey of Nigeria. Bulletin N0 42. P 84.

Akinloye, M. K., Fadipe, D. O. and Adabanija, M. A., 2002. A Radiometric Mapping of the Ladoke Akintola University Campus, Ogbomoso; Southwestern Nigeria. Science Focus Vol. 1. 55 – 61 pp.

Goodwin, A. M., 1996. Principles of Precambrian Geology. Academic Press Limited, 24-28 Oval Road, London NW1 7DX. 327 p.

Rahaman, M. A. and Lancelot, J. R., 1984. Continental Crust Evolution in S.W. Nigeria: Constraints from U-Pb dating of pre Pan-African gneisses. In: Rapport d'activite 1980-1984. Documents et Travaux du centre Geologique et Geophysique de Montpellier. 4, 41p.

Rahaman, M. A., 1988. Recent Advances in the study of the Basement Complex of Nigeria. In Oluyide, P.O., Mbonu, W.C., Ogezi, A.E., Egbuniwe, I.G., Ajibade, A.C. and Umeji, A.C. (eds.). Precambrian Geology of Nigeria, G.S.N. 11-41 pp.

Kroner, A. and Stern, R. J., 2005.Pan-African Orogeny. Encyclopedia of Geology, Elsevia, Amsterdam, Vol. 1. 1 – 12 pp.

Mehnert, K. R., 1968.Migmatites and the Origin of Granitic Rocks. Elsevier, Amsterdam.

Yardley, B. W. D., 1978.Genesis of the Skaglt Gneiss-Migmatites, Washington, and the distinction between possible mechanisms of migmatization: Geological Society of America Bulletin. Vol. 89. 941-951 pp.

McBirney, A. R., 1993. Igneous Petrology. Jones and Bertlett Publishers Inc., U.S.A.508 p.

Williams, H., Turner, F. J. and Gilbert, C. M., 1982. Petrography: An Introduction to the Study of Rocks in

Thin Sections. W. H. Freeman and Company, Sao Francisco (2nd ed). 626 p.
Wright, J. B., Hastings, D. A., Jones, W. B. and Williams, H. R., 1985. Geology and Mineral Resources of West Africa. George Allen and Unwin (Publishers) Ltd, 40 Museum Street, London WCIA 1LU, UK. 187 p.
Dada, S. S., 2006.Proterozoic Evolution of Nigeria. In: The Basement Complex of Nigeria and Its Mineral Resources. (Eds) Oshin O. 29 – 44 p.