Available online at www.pelagiaresearchlibrary.com

Pelagia Research Library

Advances in Applied Science Research, 2012, 3 (2):994-1007

ISSN: 0976-8610
CODEN (USA): AASRFC

Granitoids of the older granite suites in Southeastern Nigeria

Bassey Edem Ephraim

Department of Geology, University of Calabar, Calabar, Nigeria

---

ABSTRACT

The Older Granite suite is represented in southeastern Nigeria as in other parts of the country. In northern Obudu area, they are exposed as oval or dome-shaped isolated bodies that are sporadically distributed within the Precambrian basement complex. The granitoids, comprising mainly gneisses of monzogranitic composition, constitute the basement for the emplacements of both gabbroic and doleritic intrusions. The pervasive structural trend of the basements rocks in the N – S to NE – SW possibly point to the fact that the rocks were affected by the Pan – African orogeny. Field and petrographical evidences abound to support magmatic origin for the parent rocks of the granite gneiss. The occurrence of ferromagnesian phase(s) as isolate flakes or as oriented clots that probably followed magmatic flux direction, which is similar to the regional N –S to NE – SW foliation of the area suggest syntectonic emplacements of the granitoids. The granite gneiss is extensively dissected by a network of intersecting or crosscutting quartzofeldspathic stringers or veins/veinlets of various widths and orientations which also indicate the relevance of post-tectonic deformation and deuteric alteration in the evolutionary history of the rocks. Moreover, the granite gneiss is charged with numerous xenolithic lenses, rafts and blocks of the country rocks suggesting that one of the mechanisms of emplacement of the parent granitic rocks may have been the process of piecemeal stoping. The parent rocks were possibly emplaced into high-grade metamorphic rocks as parts of the Pan-African (600 ± 150 Ma) remobilization of the Nigerian basement. The N - S trending shear zones and other structures in the basement provided zones of weakness for the ascent of magmas, thereby causing the rocks to conform to the N - S to NE – SW structural trend of the country rocks.

Keywords: Granite, Pan–African, Obudu, Nigeria.

INTRODUCTION

The Nigerian segments of the Precambrian Tran-Saharan Pan-African orogen, in-between the West African craton and the Congo craton (Fig. 1), is related to Aïr, Hoggar, Cameroon and Borborema Pan-African (Brasiliano) provinces [1] [2] [3] [4]. And one of the characteristic features in the Precambrian geology of most of these provinces is the occurrence of a large number of granitoid bodies sporadically distributed in the basement, coeval with high-grade metamorphism [5] [6]. In Nigeria and surrounding areas, these granitoids belong to the Older Granite suites, which are clearly attributable to the Pan-African Orogeny (600 ± 150 Ma) [7], and in Brazil, comparable granitoids especially in the Borborema province are associated with the Brasiliano Orogeny [8] [9] [10]. The Older Granite suites in Nigeria were so named by Falconer [11] to differentiate them from the Mesozoic tin-bearing Younger Granite suites, which are volcanic/granitic ring complexes in the Jos Plateau area (Fig. 2). Members of these Older Granite suites show wide range of composition from granite through granodiorite, adamellite, quartz - monzonite to syenite [12] [13]. They are commonly emplaced into migmatitic rocks, high - grade gneisses and paraschists of Liberian (2700 Ma), Eburnean (2000 – 2700 Ma) and probably Kibarian (1100

Ma,) ages [14-21]. The foliated nature of some of the porphyritic granite members of the rock suites have led to their various classification as porphyroblastic granites, porphyroblastic gneisses, granite gneisses, etc [22-26].

Generally, not much is known about rocks occurring in the Precambrian terrain of northern Obudu region in southeastern Nigeria. Ejimofor et al. [25] studied Precambrian migmatitic and granitic gneisses with amphibolitic lenses/inclusions in the northwestern and slightly overlapping areas. Umeji [27] document occurrences of monzogranites in Jato Aka area. An investigation, with a view of documenting the different lithologies of an hitherto geologically unknown terrain situated northeast of Obudu in southeastern Nigeria [28] revealed that the area is especially distinguished by the preponderance, in terms of exposures, of massive granitoids in form of batholiths or granitoids of mostly acidic-intermediate compositions associated with older rocks of the region, notably migmatitic schists and gneisses (Fig. 3). These granitoids most likely form parts of the chains of major intrusions, which appear to be structurally controlled by existing North-South Pan-African trend within the basement, and possibly extend all the way from the Republic of Cameroon to the margin of the Benue Trough as suggested by Ajibade [29]. The granitoids exhibits all the attributes of the Older Granite suites [20] and, the term 'granite gneiss' is considered most appropriate for the rocks. The present research work is intended to be a detailed investigation of the field, structural and petrographical characteristics in relation to the evolutionary history of the granite gneiss of northern Obudu area (Fig. 3). It was borne out of the need to contribute towards solving the problem of inadequate investigations of the geology of the northern regions of Obudu in particular and southeastern basement complex of Nigeria in general. This paper is the first in a series of studies to be performed particularly on the granite gneiss of northeast Obudu area of southeastern Nigeria. Subsequent studies will hopefully incorporate mineral chemistry, whole-rock geochemical, geochronological and geothermobarometric data.

STUDY AREA

The area of study is situated northeast of Obudu in the southern region of present-day Benue State of Nigeria. It covers approximately 784 square kilometers delimited by latitude $6^{o}45^{'}$ and $7^{o}00^{'}$ N and longitude $9^{o}15^{'}$ and $9^{o}30^{'}$ E, and enclosed within the Nigerian topographic sheet 291 (Obudu NE) (Fig. 3). Climatic conditions in the area, like in other parts of the tropics, are characterized by the alternation of wet and dry seasons. The mean annual temperature varies from 14 – 28^{o}C and mean annual rainfall of approximately 2000 – 3000m are obtainable in the area, together with high humidity [29]. In terms of vegetation, the area lies within a zone of transition between the forested south and the Sudan Savanna. The high and luxuriant rain forest that have for a long time constrained geological investigations in southern Nigeria have given way to less dense forests and a progressively more open savanna-type of vegetation in the study area. In terms of relief, extensive high-level plains that are occasionally interrupted by sporadic isolated highland that are predominantly high-level granitoid bodies characterize the area. Most of the hills in the area have oval to conical apex that appear to have been flattened by the combined effect of exfoliation and spheroidal weathering. The average elevation of the area is in the range of about 183 metres, and very high altitudes that may exceed 900 metres are obtainable in the southeastern region of the study area. Two major rivers (Amire U Kiriki and Amire U Tamen) sculpture the landscape of the area in a North-South direction, and the channels of these rivers constitute the lowest portions of the area at both the eastern and western portions.

GEOLOGICAL SETTING

Oban Massif and Bamenda Massif are the two main geotectonic units that dominate the regional geological setting of southeastern Nigeria (Fig. 2). The Obudu Plateau constitutes part of the Bamenda Massif extensions into southeastern Nigeria. It is a vast N-S trending high-grade metamorphic terrain that form part of the Pan-African Trans-Saharan belt exposures in southeastern Nigeria. Like most parts of eastern Nigeria, it is essentially characterized by the occurrence of regionally metamorphosed rock successions, pervasive migmatization and granite plutonism [4]. The northeastern region of Obudu, on which the present study is based, is a high-grade metamorphic terrain that comprises migmatitic gneisses, migmatitic schists, granite gneisses, metagabbros, amphibolites and dolerites. The distributions and spatial association of these rocks are shown in Figure 3. For brevity, only a summary of the characteristics of rocks associated with the investigated granite gneiss are presented in this paper; details are in Ephraim [26].

The Amphibolites are highly deformed and metamorphosed, and occur mainly as dismembered enclaves, lenses and dyke-like bodies within the granite gneiss of the area. The migmatitic gneisses and schists are quartzofeldspathic in composition, and typically exhibit migmatitic characteristics. They form the basement, which has been deformed at most localities as a result of extensive invasions by magmatic rocks of mostly granitic, pegmatitic and gabbroic compositions. The metagabbroic rocks occur as lenticular to ovoid-shaped bodies at both the northern and southern regions of the study area in close association with the granitic gneiss. Dolerites are probably the only unmetamorphosed as well as the youngest rocks in northeast Obudu area, and they occur as undeformed intrusions into the granite gneiss.

FIELD AND STRUCTURAL CHARACTERISTICS

The granitic gneiss is represented in the study area by several intrusive – like granitoid bodies of obvious plutonic origin, exposed as oval or dome-shaped bodies (Fig. 4) sporadically distributed in the basement complex rocks at both the northwestern and southeastern section. These granitoid bodies often form topographic highs, display intrusive contact relationships with the country rocks, and have a dominantly north-south trending long axis which probably confirms the observation that there is a tendency towards elongation in the N-S or NE-SW directions of Older Granite bodies in the Nigerian basements [20] [27]. N-S to NE-SW direction is also the prevalent trend of foliation and fold axes of deformed basement rocks. The granitoid bodies in northeast Obudu area are completely surrounded by migmatitic gneisses at both regions in which the rock unit crop out. And despite the isolated nature of the exposures in the field (Fig. 5), it is clear from field observations that the parent granitoids belonged to a coherent granitoids body that once underlain the area. The narrow contact aureoles that this rock unit display with the hosts (migmatitic gneiss) is usually slightly chilled with some baking of the country rock often being evident at or near the contacts. Commonly the granitic rock is chilled and usually modified near the contacts, while the host migmatitic rocks are baked and consequently become more gneissose (Fig. 6).

With very few exceptions, these granitoids generally exhibit similar features. For instance, exfoliation weathering has affected all of them, giving rise to large-scale sheeting or peeling of the rocks (Fig. 7). The result of such weathering is that joint-bounded concentric shells of the rock and large fragmental boulders that appear to lie *in-situ* are rampant and constitute parts of most of the exposures. Each granitoids is typically made up of medium- to coarse-grained porphyritic granitic rock(s) near the marginal areas where it is difficult to isolate the surrounding migmatitic gneiss complex rocks due to the presence of narrow contact aureoles within the country rocks. The grain size increases very slightly inwards into the core of each of the granitoids. Within the core or central regions of the granitoids bodies, numerous well-formed or euhedral porphyroblastic crystals that are dominantly orthoclase, biotite and plagioclase are present. Granitic rock occurring within each of the granitoids is generally homogenous and weakly to strongly foliate; the foliation being parallel to the N – S trending structures of the country rocks. Distinct foliation is observable at the marginal areas, while in the core or central regions of the granitoids, such features are virtually absent. The granite gneiss, particularly those of the Ushongo region (Fig. 3), hosts a number of medium to large xenolithic inclusions of probably amphibolitic, gneissose, schistose or even reworked granitic materials in various random orientations (Fig. 8 – 10). These xenoliths, which commonly occur as pods (Fig. 8), sheets, or lenses (Fig. 9) that have been subjected to variable degree of homogenization most often display sharp margins. Rotations and relative displacements of blocks of xenolithic materials, sometimes resulting in the occurrence of minor faults with throws of about 20 to 65 cm within the host rock, have been observed within the field (Fig. 10). Within Ushongo granitoids, they exists numerous tension gashes that are quite extensive. These tension gashes widens up to 40 cm from an initial width of about 14 cm, and are not granular in texture but smooth and polished. Numerous smaller ones of about 2cm width, separated from each by about 1m gaps are also present in the area. The granite gneiss is dissected at various positions by quartzofeldspathic veins and joints, giving the rock a shattered appearance (Fig. 11). The ones that are associated with the granitoids in the southeastern margin of the area are not as numerous as those of the northern region. These quartzofeldspathic veins are dominantly zoned and composed of quartz, feldspars and minor amounts of mafic minerals. Numerous sheeted dykes of both mafic and felsic composition also invade the rock at various position. Some of these intrusions have been rotated and some slightly displaced. It is interesting to observe that the quartzofeldspathic veins often cross – cut even xenolithic materials (Fig. 12), indicating the relevance of deuteric and post – tectonic alterations in the evolutionary history of the rocks. Joints within the granite gneiss trend dominantly in the ENE-WSW direction, and sometimes the joints develop into rock pits. The contact between the granite gneiss and the country rock are best developed at Manor village in the northern region, and Usambe Village behind Binda granitoids in the southern region. These contacts are generally sharp and intrusive with narrow contact aureole. Evidence abounds to show that they must have been a significant shattering of the country rocks sometimes in the evolutionary history of the granite gneiss and that the intruding magma exhibited plastic flow.

A total of 100 measurements of foliation of rocks occurring in northeast Obudu area, including the granite gneiss, plotted on a rose diagram show that the dominant foliation trend of the rocks in the area is the N - S to NE - SW and subordinate NW-SE direction[26]. Indication is that, the granite gneiss are of northeast Obudu are among rocks possibly affected or even produced by the Pan-African thermotectonic events about 600 ± 150 Ma [1] [2] [30].

PETROGRAPHY

The petrographic characteristic of the rock is given in sufficient details elsewhere [26] [28] However, a summary is presented here. The granite gneiss is typically leucocratic with gray to greenish tint and around Manyam village in the northeastern region (Fig. 3); the leucocratic portions are light pink in colour. The luster of the rock can best be described as vitreous. The rock has a very weak layering or foliation that is most often hard to recognize as such. Its primary textures are distinctly observable in both polished and thin sections despite the fact that the original igneous mineralogy of the rock has been invariable altered to some degree due to slight metamorphism and hydrothermal/deuteric alterations. The overall texture of the rock as seen in most outcrops is best describe as predominantly hypidiomorphic granoblastic and the dominant mineral components of the rock include quartz, plagioclase, microcline and biotite.

The modal composition of the granite gneiss of northeast Obudu is presented in Table 1. Mineralogical assemblages co-existing in textural equilibrium are also listed in Table 1. Indications is that the feldspar minerals altogether constitute more than half of the rock volume, followed by quartz and biotite, while chlorite and epidote, taken together, constitute less than 3% of the rock mode (Table 1). The accessory mineral phase comprising allanite, muscovite, sphene, zircon apatite and opaque oxide make up less than 1% of the rock volume. Apart from being the most dominant, the feldspars also exhibit the most striking petrographical and mineralogical features of the rock and are easily identifiable by their lath-shaped crystals and polysynthetic twinning. Both K-feldspars (29-40%) and plagioclase feldspar (20-26%) occur in the rock. The K - Feldspar occurs sporadically in the field as large whitish to pinkish megacryst and rhomps of microcline that may measure up to 5 cm by 4 cm, giving the rock a characteristic porphyroblastic appearance. The megacrysts are distributed and aligned in a manner that suggests that they most likely originated as flow structures, whereas the rhomps are obviously weathered resistate. Plagioclase feldspar (Andesine) in the rock is subordinate to the K-feldspar with an average modal composition of about 22% (Table 1). Considering all the samples studied, the plagioclase composition varies between An_{26} to An_{31} (oligoclase to andesine).

Quartz ranks next to the K-feldspar with an average modal composition of 28.4%. Two generations of quartz are present in thin sections of the rock. The late and most prominent quartz type commonly occurs as anhedral or irregularly shaped composite granoblastic crystals that are elongated parallel to the N – S and NW – SE directions, thereby contributing to the linear fabric of the rock. Biotite is the dominant mafic mineral present in the granite gneiss of northeast Obudu, and it constitutes 12.3% of the rock. In the field, the biotite occurs as isolate flakes or, as oriented clots, possibly following the magmatic flux direction which appears to be the same as the regional foliation of the area. Chlorite, epidote and sericite are clearly displayed as replacement or alteration products in all the thin sections of the rock studied. The chlorite crystals are commonly sandwiched between two biotite flakes, while sericite and epidote often occur as inclusions within the feldspars as well as along the edges of some of the feldspars. Epidote may be accompanied by apatite or allanite. Accessory minerals present within the rock are traces of apatite and zircon, which are both commonly concentrated in biotite. Sphene with its characteristic spindle shape also occurs in the rock in concentrations that is close to 1%. Also present in the rock, are minor amount of disseminated opaque oxides, rutile, monazite, allanite and shred-like muscovite that have obviously formed along feldspar grain boundaries or intergrown with quartz.

Following the classifications of igneous rocks according to the IUGS recommendations [31] [32] [33] [34] involving the plotting of modal compositions on the double QAPF triangles for granitoids rocks, the granite gneiss is dominantly monzo-granitic *sensu stricto* in composition (Fig. 13).

DISCUSSION

The magmatic origin of the precursor rocks to the granite gneiss of northeast Obudu area is clearly established by the following lines of evidence:

1. The intrusive nature of the rocks, which is amply supported by the sharp contact relationship displayed by the various granitoid bodies with the country rocks;
2. The presence of a more coarser crystallinity in the core than at marginal areas of each of the granitoid bodies;

3. The incorporations of numerous xenolithic blocks that are often associated with slight displacements and/or rotations;
4. The developments of myrmekitic intergrowths at the plagioclase–alkali feldspar–quartz triple junctions, which also suggest the relevance of late magmatic/deuteric crystallization in the evolutionary history of the rocks [27]
5. The occurrence of microcline microperthite and complete absence of antiperthitic features in all the thin sections examined;
6. The parallel alignment of flaky and platy minerals in a manner that suggest control by magmatic flux.

The presence of xenoliths in a rock body does not only indicate the magmatic character of the parent granitic rocks, but also give indication of the mode of emplacements of the rock [35]. Harker [36] long ago observed that magma could shoulder aside country-rocks or 'roof' in making space for itself, and in so doing is seen to be charged with xenoliths of the displaced country-rocks. Xenoliths are actually evidence that a rock body was emplaced by the process of stoping [37]. The modes of emplacement of magmatic rocks reviewed by Pitcher [38] [39] and Ehlers and Blatt [40] include, shouldering aside and updoming of country rocks, a combination of cauldron subsidence and cauldron upheaval and stoping. The granitic gneiss of northeast Obudu area are charged with numerous xenolithic lenses, rafts and blocks of the country rocks, therefore one of the mechanisms of emplacement of the parent granitic rocks may have been the process of stoping; most likely, piecemeal stoping.

Although geochemical data is not parts of the present research, it is not unreasonable to classify the pre-metamorphic lithology of the granite gneiss of northeast Obudu area as parts of the Older Granites suites of Nigeria, and such conclusion is based on the underlying observations:

1. The rocks exhibits most, if not all, of the field characteristics of the Older Granites suites, including its magmatic character and association with gabbroic bodies [26];
2. The rocks are coarse to very coarse textured or porphyritic in nature, which is typical of most members of the Older Granite Suites. The implication is that members of the Older Granite Suites experienced slow cooling of their magmatic melt, resulting in mineralogical features such as the occurrence of large whitish to pinkish megacryst and rhomps of microcline;
3. The elongation of granitoid bodies in the N-S to NE-SW direction is a characteristic that is also associated with the Older Granite suites [27].
4. Finally, the granite gneiss of northeast Obudu, like other members of the Older Granite suites, was produced by the Pan-African thermotectonic events. The rose diagram plots about 100 measurements of foliations of rocks occurring in northeast Obudu area, including the granite gneiss, define N-S to NE-SW direction as the dominant trend [26].

One paramount problem in the study of rocks of the Older Granite suites in Nigeria has been the interpretation of the foliated nature of the rocks in relation to the evolutionary history of the rocks. Consequently, [41] [42] [43] [20] etc have advanced various views in this regard. And until a much more acceptable view is advanced, the foliation in the granite gneiss of northeast Obudu area are interpreted for now as imprints of metamorphism, which is not yet clearly understood.

It is a common fact that granitoids of the Older Granite suites were emplaced into the metamorphic basement complex of Nigeria during the (600 ± 150 Ma) Pan-African events. Ajibade [20] advanced the view that the N - S trending shear zones and other structures in the basement possibly provided zones of weakness for the ascent of magmas, thereby causing the granitoids bodies to conform to the N - S to NE – SW structural trend of the country rocks. In northeast Obudu area, this is supported by the occurrence of ferromagnesian phase(s) as isolate flakes or as oriented clots that followed magmatic flux direction, which is similar to the regional N –S to NE – SW foliation of the area. The conformity of the Older Granite suites of Nigeria with the N - S structural grain of the country can been used as evidence of syntectonic emplacements of the granitoids. However, strands of evidence that also indicates the relevance of post-tectonic emplacements in the evolution history of this rock unit(s) abound, and include:

1. The presence of minor faults with throws of about 20 to 65 cm within the granite gneisses;
2. The rotations and relative displacements of blocks of xenolithic materials.
3. The network of intersecting or crosscutting quartzofeldspathic stringers or veins/veinlets of various widths and orientations that extensively dissected the granite gneisses.

Further research, including geochemical, isotopic and geothermo-barometric studies, will definitely throw more light on the evolutionary history of the granite gneisses of northeast Obudu in southeastern Nigeria.

TABLE 1. Modal compositions of granite gneiss of the northeast Obudu area, Southeastern Nigeria

	GG17	*GG18*	*GG19*	*GG20*	*GG21*	*GG22*	*GG23*	*GG24*	*GG25*	*GG26*	*GG27*	*GG28*	*MEAN*
Quartz	28	25	29	28	29	29	30	31	30	27	27	28	28.4
Plagioclase	24	20	22	20	22	20	26	23	24	20	25	23	22.4
K-Feldspar	40	30	36	30	29	35	36	31	32	36	30	35	33.3
Biotite	6	16	10	13	17	13	8	12	14	9	18	12	12.3
Chlorite	1	2	2	6	2	1	tr	2	tr	2	tr	2	1.7
Epidote	1	2	1	3	1	2	tr	1	tr	6	tr	tr	0.4
Sericite	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
Staurolite?	-	5	-	-	-	-	-	-	-	-	-	-	-
Allanite	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
Sphene	tr	tr	tr	tr	tr	1	tr	tr	tr	tr	tr	tr	tr
Zircon	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
Apatite	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
Opaque	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
Mineralogical	*Qtz – Andesine – Biot - Microcline*												

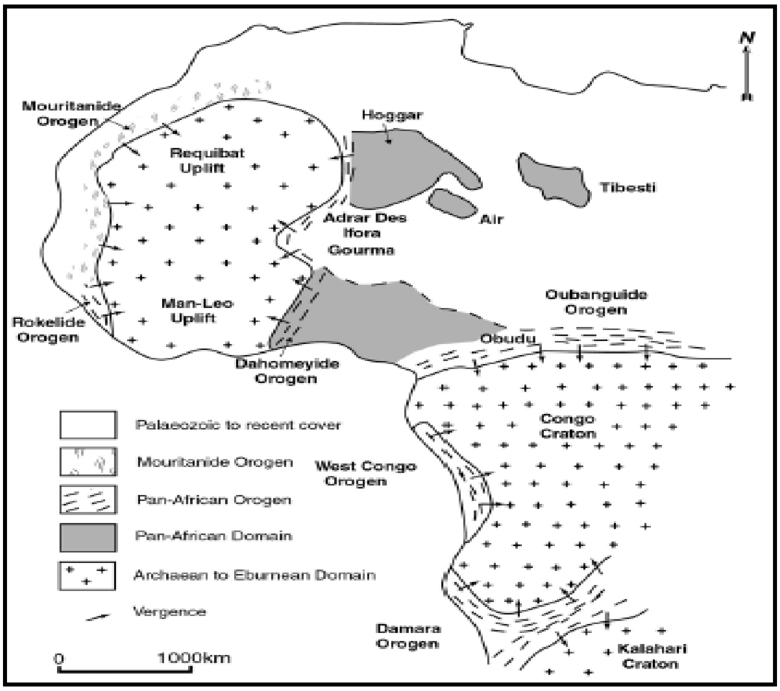

Fig 1. A generalized geotectonic map of Africa showing the location of Obudu, southeastern Nigeria
(Modified after Affaton et al., 1991).

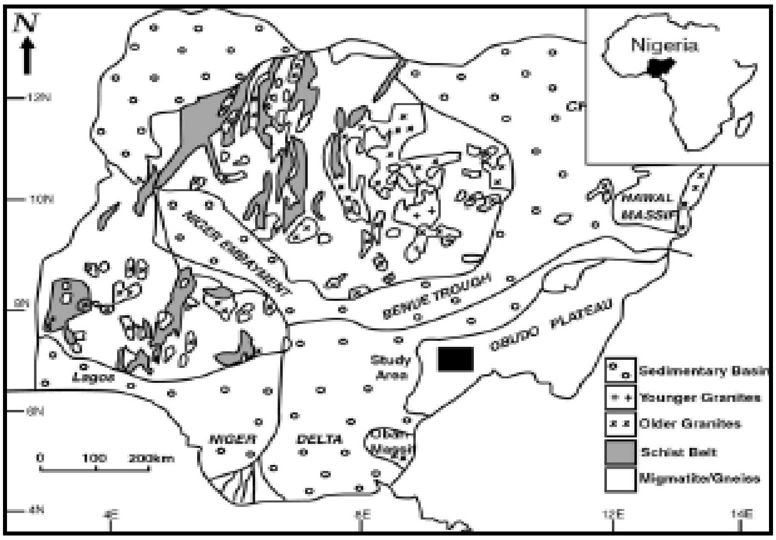

Fig. 2. A simplified geological map of Nigeria showing the location of the study area
(modified after Woakes et al., 1985 and Olarewaju, 1998)

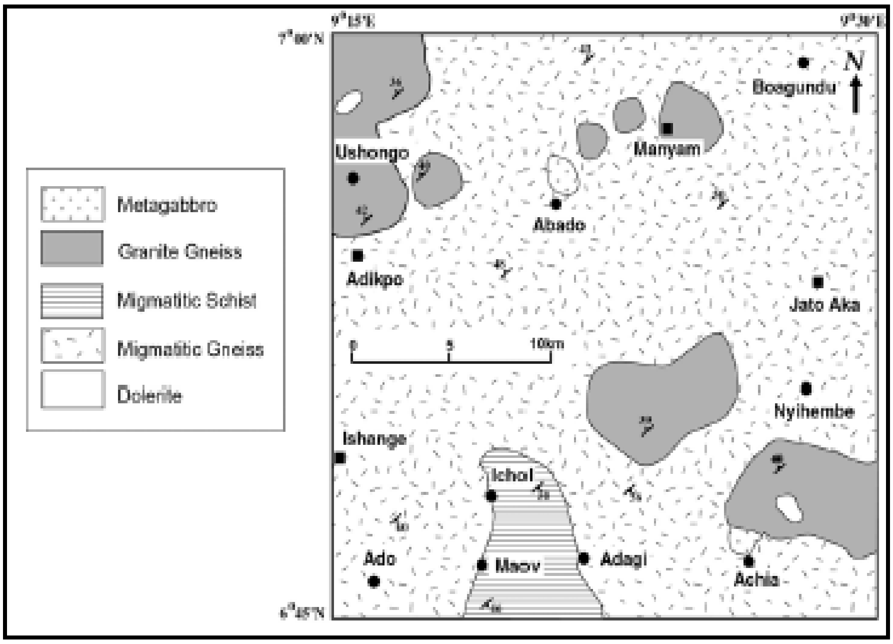

FIG. 3. Geological map of northeast Obudu, Bamenda massif, southeastern Nigeria

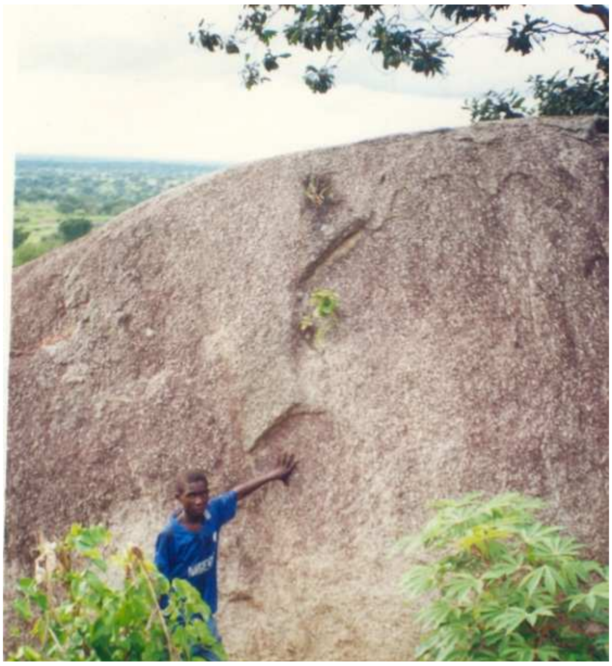

Fig. 4. A typical outcrop of the granite gneiss of northeast Obudu, exposed as oval or dome-shaped body

Fig. 5. Isolated nature of the granite gneiss of northeast Obudu

Fig. 6. The contact area, showing the host migmatitic rocks being baked to become more gneissose in appearance, while the granitic rock is chilled and modified

Fig. 7. Exfoliation influence on the granite gneiss of northeast Obudu. Note the joint-bounded concentric shells of the rock

Fig. 8. Pods – like xenolithic bodies occurring in the granite gneiss of northeast Obudu.

Fig. 9. Xenolithic lenses in the granite gneiss of northeast Obudu

Fig. 10. Minor faults occurring within the granite gneiss of northeast Obudu

Fig. 11. Shattered appearance of the granite gneiss of northeast Obudu, due to dissection by quartzofeldspathic veins and joints at various positions

Fig. 12. Quartzofeldspathic veins cross – cutting xenoliths in the granite gneiss of northeast Obudu

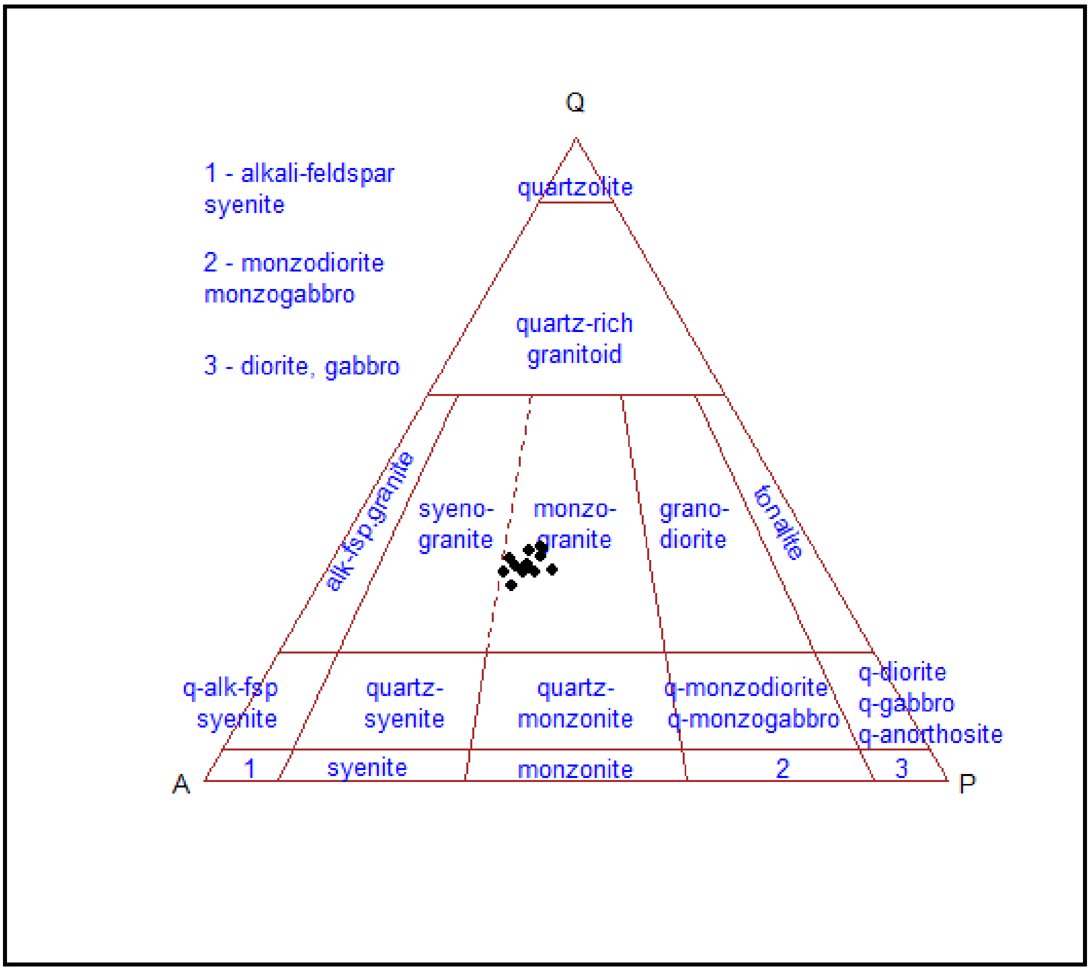

Fig. 13. Classification of the granite gneiss of northeast Obudu on the double QAPF triangles
(Le Maitre 1989, Streickeisen 1976, Shelley 1993, Hyndman 1985)

CONCLUSION

Granitoids of the Older Granite suites were emplaced into the metamorphic basement complex of Nigeria during the (600 ± 150 Ma) Pan-African events. The granite gneiss occurring in the area situated northeast of Obudu in southeastern Nigeria form parts of these Older Granites suites. In outcrops of this granite gneiss, isolate flakes or oriented clots of ferromagnesian phase(s) present appear to follow magmatic flux direction which is similar to the regional N –S to NE – SW foliation of the area. These points to the fact that the granitoid rock bodies are probably structurally controlled by existing trends in the basements.

Field and petrographic characteristics confirm that the granitic parent rock most likely had magmatic origin, and that one of the mechanisms of emplacement of the parent granitic rocks may have been the process of piecemeal stoping. Both syn-tectonic and post-tectonic emplacements were probably relevant in the evolutionary history of the rock unit(s).

It is hoped that further research work on the granite gneiss, including geochemical, isotopic and geothermobarometric studies, will throw more light on the evolutionary history and tectonic setting of the rock unit(s).

Acknowledgements
This work has benefited immensely from the wealth of knowledge of Prof. Barth N. Ekwueme of the department of Geology, University of Calabar. The assistance of Mr. Iorfa Christopher Adamu during the field aspect of this work is also gratefully acknowledged.

REFERENCES

[1] W. Q.Kennedy, Res. Inst. African Geology, University of Leeds. 8th Rep., **1964,** 48 - 49.
[2] T. N. Clifford, In: TN Clifford and I G Gass (Eds.) African magmatism and tectonics. Oliver and Boyd, London, **1970**, pp. 1-20.
[3] R. Caby, A. N. Sial, M. Arthaud and A. Vauchez, In: R. D. Dallmeyer and J. P. Lécorché (Eds.), The West African Orogen and Circum-Atlantic Correlatives. Springer Verlag, Berlin, **1991**, pp. 373 - 397.
[4] E. Ferré, J. Déléris, J. L. Bouchez, A. U. Lar and J. J. Peucat, *J. Geol. Soc. Lond.*, **1996**, *153: 719 - 728*.
[5] P. Affaton, M. A. Rahaman, R. Trompette, and J.Sougy, In: R. D. Dallmeyer and J. P. Lécorché (Eds.), The West African Orogen and Circum-Atlantic Correlatives. Springer Verlag, Berlin, **1991,** pp. 107 -122.
[6] I. P. Guimarāes, C. N. Almeida, A. F. Da Silva Filho, and J. M. M. Araújo, *Rev. Bras. Geoc.*, **2000**, *30(1), 177-181*
[7] A. C. Ajibade and W. R.Fitches, In: P. O. Oluyide (ed.) Precambrian Geology of Nigeria, Geological Survey Publication, Nigeria, (**1988**), pp. 45-53.
[8] A. Vauchez, S. P. Neves, R. Caby, M. Corsini, M. Egydio-Silva, M. Arthaud and V. Amaro, *J. South Amer. Earth Sci.*, **1995**, *8, 247-266.*
[9] A. F. Da Silva Filho, I. P. Guimarāes, M. F. L. Brito, and M. M. Pimentel, *Int. Geol. Rev.*, **1997,** *39, 639 – 659*
[10] I. P. Guimarāes, A. F. Da Silva Filho, C. N. Almeida, W. R. Van – Schmus, J. M. M. Araújo, S. C. Melo, E. B. Melo, Precambrian Research, **2004**, 135, 23–53
[11] J. D. Falconer; *The Geology and Geography of Northern Nigeria*. Macmillan Publishers, London, **1911**
[12] M. A. Rahaman, In: C. A. Kogbe (Ed.), Geology of Nigeria. Elizabethan Press, Lagos, **1976**, pp. 41-58.
[13] P. I. Okeke, T. Akinnagbe and L. O. Anike, *J. Min. Geol.*, **1988**. *24 (1 and 2), 31 -90.*
[14] N. K Grant, *Earth Planet. Sci. Lett.*, **1970**, 10, 29 - 38.
[15] V. M. Oversby, Earth and Planetary Science Letters, **1975**, 27, 177 - 180.
[16] B. N. Ekwueme, Prec. Res., **1987**, 34: 269 289.
[17] N. K. Grant, Bulletin of the Geological Society of America, **1978**, 89, 50 - 58.
[18] J. M. L. Bertrand and R. Caby, *Geol. Rundsch*, **1978**, *67, 357 – 388*.
[19] A. Ogezi, PhD thesis, University of Leeds (Leeds UK, **1977**).
[20] A. C. Ajibade, *Nig. J. Min. Geol.*, **1982**, *19(1), 221 - 230*.
[21] M. A. Rahaman, In: P. O. Oluyide (Ed), Precambrian Geology of Nigeria, (Geological Survey Publication, **1988**), pp. 11 – 43
[22] M. O. Oyawoye, In: T. F. J. Dessauvagie and A. J. Whiteman (Eds.), African Geology. University of Ibadan Press, **1972**, pp. 67-99.

[23] P. McCurry, *Overseas Geology and Mining Resources, London,* **1973,** *45, H. M. 50, 45p.*
[24] P. McCurry, In: C. A. Kogbe (ed.), Geology of Nigeria (Elizabethan Press, Lagos, **1976),** pp. 15-39.
[25] O. C. Ejimofor, A. C. Umeji., U. M. and Turaki, *J. Min. Geol.*, **1996,** *32, 1 - 9.*
[26] B. E. Ephraim, PhD thesis, University of Calabar (Calabar, Nigeria, **2005**)
[27] A. C. Umeji, *J. Min. Geol.*, **1991**, *27 (1), 115 - 128.*
[28] B. E. Ephraim, B. N. Ekwueme and I. C. Adamu, *International Journal of Natural and Applied Sciences*, **2005**, 1, 1, pp. 84 – 89,
[29] A. L. Mabogunje In: Africa South of the Sahara (Europa, England, **1983**), 769-770
[30] B. N. Ekwueme; The Precambrian geology and evolution of the southeastern Nigerian basement complex. Calabar, University of Calabar Press, **2003,** 135p.
[31] A. W. Streckeisen, Earth Sci. Rev., **1976,** 12 (1), pp. 1 - 33.
[32] R. W. Le Maitre, P. Bateman, A. Dudek, J. Keller, M. J. Le Bas, S. A. Sabine, R. Schmidt, H. Sorensen, A. Streckeisen, A. R. Woolley, and B. Zanettin; *A Classification of Igneous Rocks and Glossary of Terms.* Blackwell Publishers, Oxford, **1989.**
[33] D. Shelley; *Igneous and metamorphic rocks under the microscope - classification, textures, microstructures and mineral-preferred orientations,* Chapman and Hall, London, **1993**.
[34] D. W. Hyndman; *Petrology of the Igneous and Metamorphic Rocks.* 2nd edition. McGraw-Hill, USA, **1985**.
[35] F. A. Hatch, A. K. Wells and M. K. Wells; *Petrology of the Igneous Rocks*. George Allen and Unwin, London, **1974**.
[36] A. Harker; *The Natural History of Igneous Rocks*. Macmillan, New York, **1909**.
[37] B. N. Ekwueme; *An easy approach to igneous petrology*, University of Calabar Press, 1993.
[38] W. S. Pitcher, J. *Geol. Soc. Lond.*, **1978,** *135, 157-182.*
[39] W. S. Pitcher, J. *Geol. Soc. Lond.*, **1979,** *136, 627 - 662.*
[40] E. G. Ehlers and H. Blatt; *Petrology – Igneous, Sedimentary and metamorphic.* W. H. Freeman, New York, **1982**.
[41] M. O. Oyawoye, *J. Min. Geol.*, **1964**, *1, pp. 87 - 102.*
[42] F. H. Hubbard, *Geol. Soc. Amer. Bull., 1975, 86, pp. 548 - 554.*
[43] M. I. Eborall, In: C. A. kogbe (Ed.), Geology of Nigeria (Elizabethan Publishing Co., Lagos, **1976**), pp. 65-74.