INTERNATIONAL JOURNAL OF NATURAL AND APPLIED SCIENCES (IJNAS) VOL. 1, No. 1: pp. 84 – 89, 8 FIGS.

Preliminary report on the geology of northeast Obudu, Bamenda massif, southeastern Nigeria.

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ABSTRACT

The hitherto geologically unknown area situated northeast of Obudu in southeastern Nigeria is composed dominantly of a floor of high-grade metamorphosed rock successions, which are essentially quartzo-feldspathic gneisses and schists that exhibits migmatitic characteristics. These assemblages are intruded at various locations by prominent exposures of mostly granitic and subordinate gabbroic rocks that have also been metamorphosed to various grades. Other rocks mapped in the area are unmetamorphosed dolerite and xenolithic enclaves of amphibolites occurring mostly in the granite gneiss. The measured dominant foliation trend of N-S to NE-SW direction, associated with the predominantly northwesterly dip directions in the rocks of the area indicate that most of these rocks were probably affected by the Pan-African thermotectonic events (550 ±100 Ma). The proximity of the area of study to western Cameroon and the similarities of the rocks of northeast Obudu area to basement units occurring in the Western Cameroon Domain permit the consideration of northeast Obudu area as a westward prolongation of Precambrian terrains of Cameroon into southeastern Nigeria.

Keywords: Northeast Obudu, amphibolites, granite, migmatite, metagabbro

INTRODUCTION

Southern Obudu has in the past benefited immensely from diverse and repetitive studies (Orajaka, 1964, 1971; Umeji, 1988; Ekwueme, 1990, 1991,1994a, 1994b, 1998; Ephraim, 1992; Ekwueme and Matheis, 1993; Ekwueme *et al*., 1997; Ekwueme and Kroener, 1997, 2000, 2001; Ukwang, 1998; Ukwang *et al*., 2003; Ukaegbu, 2003), such that the geology of most parts of the area is now well understood. In contrast, the northern regions of Obudu suffered neglects over the years. This has resulted in most parts of the region being classified among geologically unknown terrains in southeastern Nigeria. To the best of our knowledge, apart from Ejimofor *et al.* (1996) and Umeji (1991), no other published work existed on this region before now. While Ejimofor *et al*. (1996) reported the occurrence of Precambrian migmatitic and granitic gneisses with amphibolitic lenses/inclusions in the northwestern and slightly overlapping region to the present study area, Umeji (1991) documents occurrences of monzogranites in Jato Aka area, also adjacent to the present study area, but in the east.

The intention of the present contribution is to document the basement units preserved in northeast Obudu area. The desire to have an overall picture of the whole of Obudu area is the impetus for the work. Because northeast Obudu area constitutes parts of the eastern political boundary of Nigeria with the Federal Republic of Cameroon, this study will, among other benefits, facilitate correlations with basement terrains in Cameroon. Such correlations will definitely throw more light on the crustal evolutionary history/ geodynamic setting of the region. It might also aid in mineral exploration and environmental managements.

Description of study area

The area of investigation covers approximately 784 square kilometers, and is situated in the northeastern part of Obudu in the southern region of present-day Benue State of Nigeria (Fig. 1). It is delimited by latitudes $6^{o}45^{'}$ and $7^{o}00^{'}$ N and longitudes $9^{o}15^{'}$ and $9^{o}30^{'}$ E, and enclosed within the Nigerian topographic sheet 291 (Obudu NE). The area lies within a zone of transition between the forested south and the Sudan Savanna. And the high and luxuriant rain forest that are prominent features in the south have given way to less dense forests and a progressively more open savanna-type of vegetation. 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

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Manuscript received by the Editor September 27, 2004; Revised manuscript accepted August 19, 2005.
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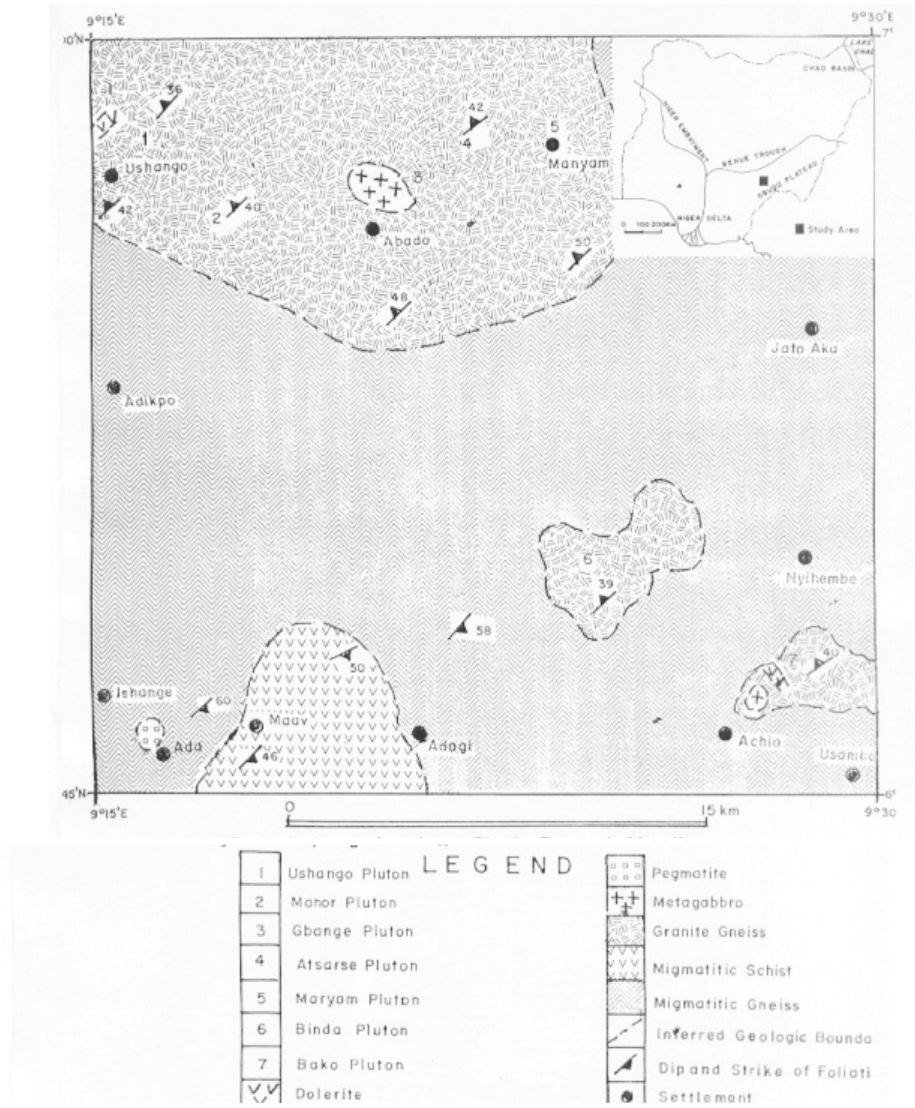

Fig. 1. Geological map of northeast Obudu, Bamenda Massif. Inset: An outline map of Nigeria showing the location of the study area in southeastern Nigeria.

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 at both the eastern and western portions. The channels of these rivers constitute the lowest portions of the area. Climatic conditions in the area, like in other parts of the tropics, is 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 (Udo, 1970; Duze and Ojo, 1977; Mabogunje, 1983).

METHODOLOGY

The method of study adopted involved geological field mapping with conventional instruments. A reconnaissance field investigation was first conducted in the area, followed by detailed study. During the reconnaissance stage of the fieldwork, it was thought wise to use a global positioning system (Magellan 300 GPS) to update the base map to reflect the positions and names of the towns, major villages, and other settlements that were lacking in the base map, for ease of location and referencing during the fieldwork proper. Detailed fieldwork was carried out during the harmattan period because it is at this period that the land is commonly dry and clear of vegetation for ease of accessibility. In the course of the fieldwork, adequate attention was paid to the nature of the topography and vegetations at each site, since both topography and vegetations are known to reflect geology (Barnes, 1981; Ekwueme, 2004), and therefore invaluable in geological mapping exercises.

BASEMENT UNITS IN NORTHEASTERN OBUDU AREA

Crystalline basement rocks that form parts of the basement complex of Nigeria underlie northeast Obudu area. The distributions of the various rock types, together with their structural orientations, are presented in Figure 1. The field/megascopic observations supports the classification of the mapped rocks into 6 sub-groups, namely:

1. Amphibolites
2. Migmatitic Gneiss;

3. Migmatitic Schists;
4. Granite Gneiss;
5. Metagabbro and;
6. Dolerites

Amphibolites

Amphibolites appear to be the oldest rock in northeast Obudu area. These rocks occur mainly as dismembered enclaves within the granite gneiss of the area (Fig. 2). Field exposures of this rock unit show that they are highly deformed and metamorphosed. The orientation of their lensoid or dyke-like forms is not consistent; some are discordant, while others are concordant to the N-S regional foliation. In hand specimens, these amphibolites are typically dark gray in colour, fine to coarse textured, massive or slightly foliated.

Fig. 2. Amphibolite enclaves in an outcrop of granite gneiss.

Migmatitic gneiss

Quartzo-feldspathic gneisses are the dominant rock types in northeast Obudu area. Exposures of this rock unit are well developed in areas bordering the felsic intrusives, and outcrop within the southern region. The ones behind Binda and Baku plutons, are quite extensive and display good structural features. The gneissic rocks in northeast Obudu area commonly display migmatitic characteristics, and they form the basement, which has been deformed at most localities as a result of extensive invasion by rocks of mostly granitic, pegmatitic and gabbroic compositions. They have been extensively weathered at some localities, such as in the central region of map area (Fig. 1). The extensive lateritic cover that exists further away from the felsic intrusives most likely represents in-situ weathered products of an original crystalline gneiss complex. This is because on most roadside cuttings, foliation traces preserved can be traced from the ground surface into the underlying crystalline rocks. Also these traces have been found to be consistent with values measured from crystalline migmatitic gneiss outcrops, where prominent foliations exist. Such prominent foliations are defined by preferred mineral orientations (Fig. 3) and bandings (Fig. 4). These foliation trends are dominantly in the N – S to NE – SW directions with steep westerly dips.

Fig. 3. Migmatitic gneiss outcrop with stretched lineations near Adagi village.

Fig. 4. Migmatitic gneiss outcrop with thin and well developed quartzofeldspathic bands near Ishange Town.

Migmatitic schists

Banded schists and locally homogenous varieties also constitute major rock types occurring within northeast Obudu area (Fig. 1). They occur within the south-central regions of northeast Obudu area adjacent to the migmatitic gneiss, and extend outside the map area southwards. In addition, small scattered masses of medium to high grade schists have been observed to occur as pods and extensive sheets within the granite gneiss in spite of the fact that elsewhere these two rock types do not have any contact relationship. Like the gneissic rock, the schists are also frequently migmatitic and form parts of the basements into which the felsic and mafic plutons are intruded.

Most outcrops of migmatitic schist within northeast Obudu area are extensively weathered. In some places, such as within the Amiri U Kiriki river bank and channel, the schists are conspicuously layered, occasionally displaying well preserved beddings (Fig 5) and other synsedimentary deformational structures. Foliation trends in the schist are also dominantly consistent in the N-S to NE-SW direction.

No contact relationships has yet been observed in the field between the migmatitic gneiss and schists, but spatial configurations of both rock type suggests that the schist may be relatively younger and were probably supracrustals on the gneissic rocks of the area. However, more work, including geochronological data, on the schist

Fig. 5. Migmatitic schist outcrop with well developed schistosity near Amire U Kiriki River Bank.

will definitely lead to a better conclusion on the chronology and structural relationship between these two types of rocks.

Granite gneisses

Several intrusive granitoid bodies of obvious plutonic character are well exposed as oval or dome-shaped bodies (Fig. 6) sporadically distributed in the basement complex rocks at both the northwestern and southeastern regions of the study area. They form topographic highs, and display intrusive contact relationships with the country rocks. The granitoid bodies also have a dominantly north-south trending long axis, and are completely surrounded by migmatitic gneiss at both regions that the rock unit crop out. Despite the isolated nature of the exposures in the field, it is clear from field observations that these granitoids belong to a coherent plutonic body that underlie the area. They probably constitute parts of the chains of intrusions that extend from the Republic of Cameroon to the margin of the Benue Trough. 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.

Fig. 6. Massive oval- to dome-shaped granitoid outcrop (Bako Pluton) on Kpe Hill.

Commonly the granitic rock is chilled and usually modified near the contacts, while the host migmatitic rock is baked and consequently become more gneissose. The granitic rocks in northeast Obudu area are slightly foliated and are therefore classified as granite gneiss. The field relationships and petrographic features of this granite gneiss are treated in sufficient details in Ephraim (2005).

Metagabbro

Mafic rocks of essentially gabbroic compositions occur at both the northern and southern regions of the study area in close association with the granite gneiss (Fig. 7). They appear to have been metamorphosed and at both locations they occur as lenticular to ovoid-shaped bodies. In some locations, exposures of the rock exist as scattered boulder (Fig. 7). Although no contact relationships with the granite gneiss have yet been observed, spatial configuration suggest that the granite gneiss constitute the basement on which the metagabbroic rock was intruded.

Fig. 7. Outcrop of metagabbro at Nto Hill in the northern region of the study area.

Dolerites

Dolerites constitute the youngest rock in northeast Obudu area, and they occur as intrusions into the granitoid of the area. The only dolerite outcrop mapped within the area intrudes the granite gneiss of Ushongo pluton. The second outcrop could not be easily traced, in spite of the fact that sufficient traces such as very large boulders of the rock abound, and were found associated with boulders of metagabbroic rocks at Nto hills (Fig. 7) in the southern region of the area.

Mesoscopically, the dolerites are fresh, dense, dark in colour, and generally fine to medium-grained. They do not show any effect of hydrothermal or deuteric alterations and are ophitic to sub-ophitic textured. Moreover, these dolerite are largely unmetamorphosed, undeformed and commonly display chilled margins with its host (Fig. 8).

SUMMARY AND CONCLUSIONS

The hitherto geologically unknown area situated northeast of Obudu in southeastern Nigeria constitutes parts of the basement complex of Nigeria. The basement units occurring in this area include amphibolites, migmatitic gneiss, migmatitic schist, granite gneiss, metagabbro and dolerites.

Fig. 8. Scattered boulders of metagabbro and dolerite at Nto Hill.

A total of 100 measurements of foliation of the rocks of northeast Obudu area plotted on a Rose diagram show that the dominant foliation trend of the investigated rocks is in the N-S to NE-SW direction, indicating that most, if not all, the rocks occurring within northeast Obudu area were most likely affected or even produced by the Pan-African thermotectonic events (550 ±100 Ma) (Kennedy, 1964; Clifford, 1970; Ekwueme, 2003). The only exception in this regard is probably dolerite since this unit is largely un-metamorphosed.

It is possible that northeast Obudu area constitute a westward prolongation of Precambrian terrains of Cameroon into southeastern Nigeria (Ekwueme, 2003; Toteu, 2001, 2004). This is because:

(1) Most of the rocks occurring in the area were most likely affected or produced by the widespread Pan-African thermotectonic events;

(2) Northeast Obudu area is in close proximity to western Cameroon;

(3) The basement units occurring in northeast Obudu area are similar to the ones in Western Cameroon.

The migmatitic gneisses and schists are correlatable with the Poli-metavolcanosedimentary series in the adjoining Cameroon, while the granitic intrusions probably constitute parts of the chains of pre-, syn- to late-tectonic granitoid intrusions that extend from the Republic of Cameroon to the margin of the Benue Trough (Ajibade, 1988; Toteu, 1990; Toteu *et al*., 2001, 2004).

With this contribution, northeast Obudu area is undoubtedly 'opened' for future research and development. The present work provides a basis for future study of the geology of the area in particular, and the eastern basement complex of Nigeria in general. It may also assists in the development of Northern Obudu area.

ACKNOWLEDGEMENTS

Our gratitude goes to the natives of Mbaikyiaa and Ikov districts in Ushongo Local Government Area, the natives of Turan and Nanev districts in Kwande Local Government Area, and the natives of Shangev-ya District in Vandekyia Local Government Area; all of present-day Benue State of Nigeria, for their cooperation and assistance during the field aspect of this study. Comments and suggestions of colleagues in University of Calabar are also gratefully acknowledged. Dr. M. I. Oden graciously supplied the GPS that was used throughout the fieldwork, and for this, we owe him an appreciation. We are also grateful to Mr. Umana of the Department of Geology, University of Calabar for drafting the Geological map of northeast Obudu area employed in this write-up.

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