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A Geologic Field Report on the Geology of Part of the Oban Massif and Calabar Flank, South Eastern Nigeria

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***Abstract*—** *The study area is situated within the Oban Massif and the Calabar Flank of southeastern Nigeria. The rocks that make up the area are basically basement complex rocks, metasediments and late cretaceous sedimentary rocks. During the exercise, granodiorites, quartzite, gneiss, pegmatites vein were identified as well as sedimentary rocks and their associated structures. Presence of minerals such as biotite, hornblende, quartz, orthoclase, muscovite, and plagioclase were identified. The study shows that the study areas have undergone series of igneous, metamorphic and sedimentary processes.*

I. INTRODUCTION

The Oban Massif which is part of the Nigerian basement complex occupies about 10,000km^2 in the South Eastern part of Nigeria (Barth Ekwueme, Eyo Nyong, Sunday Peters, (1995). It is bounded in the North–Western region by the Abakaliki anticlinorium and the Mamfe embayment in the North. The geologic map of the Oban massif shows it has a complex lithology and the differentiation of the rock types has remained difficult until recent times.

The difficulty arises from the fact that the Oban Massif is located in the thick equatorial rain forest. And secondly, rock outcrops in the area are generally intensely weathered and this makes it difficult to obtain fresh rocks for geologic studies.

Parts of the study area also include the Calabar Flank. The term Calabar Flank was first proposed by Murat (1972) for that part of Southern Nigeria sedimentary, basin characterized by crustal block fault tending in a NW-SE direction. Many hypotheses have been proposed to account for the origin of the Southern Nigerian sedimentary basin including the Calabar Flank.

The study of the area shows the occurrence of metamorphic gneisses, quartzite etc. They are introduced by igneous rocks such as granodiorite etc. The cretaceous sediments are basically sandstones, shales and shaly limestone as well as impure limestone the area is believed to have been affected by series of organic processes as well as marine transgressions and regressions.

Location and Accessibility

The study locations are all along the Calabar Ikom highway and Calabar-Itu road. They can be accessible by car or foot. Accessibility to outcrops where made possible by minor roads and footpaths

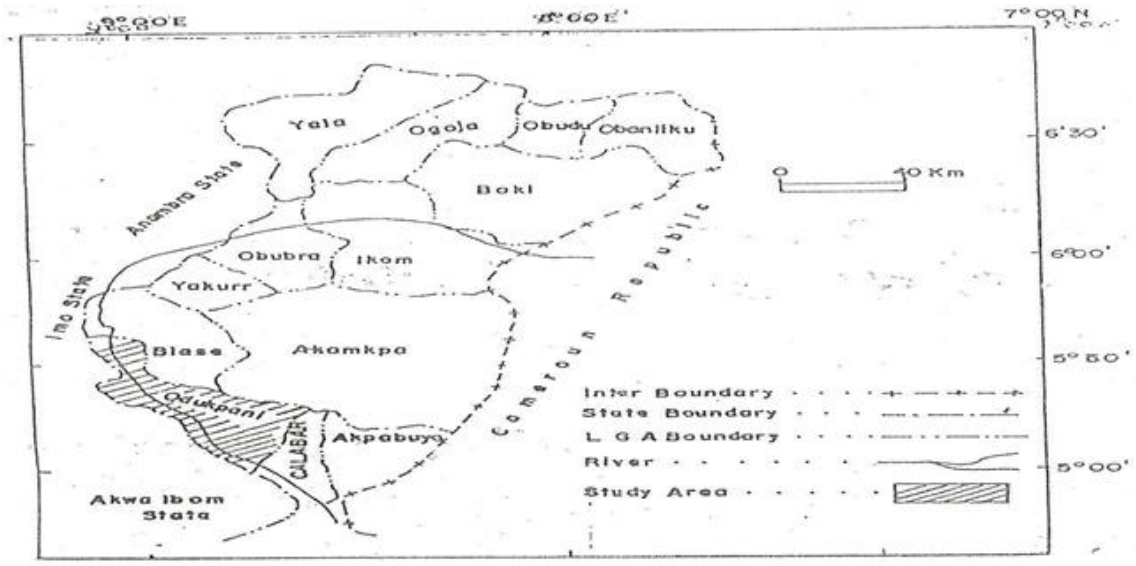

Fig. 1. Map of Cross River State showing study area.

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II. Literature Review

The first survey of the geology of Nigeria was undertaken immediately after the establishment of the geological survey of Nigeria in 1919, under the directories of Dr. J.D. Falconer. After this, quite a lot of workers have worked on different localities within the basement complex. Such work includes Leblance (1979 & 81), Burke and Deway (1981), Ekwueme (1987, 90, 94) among others.

Nigeria, Occupies about 10,000km^2 and includes mappable metamorphic rock units as philites, schists, gneisses and amphibolites. These rocks were thought to be introduced by pegmatite, granites, granodiorites, diorites, tonalities, monazite and dolerites (Ekwueme, 1990).

Three lithologic units have been recognized within the basement complex (Oyawoye, 1972) and Ekwueme and his co-worker has established the age of the Oban massif. The basement complex is believed to have undergone series of igneous and metamorphic deformation (Ekwueme, 1990) and is overlain by cretaceous to tertiary sedimentary rocks which forms part of the Calabar Flank. As said earlier the Calabar Flank in current usage is that part of Southern Nigeria basin that is bounded by the Oban massif to the North and the Calabar hinge line delineating the Niger Delta basin in the South. It is also separated from the Ikpe platform to the west by a NE-SW trending fault. It was affected by two major tectonic phases. Marine transgression and regressions also plays important role in the formation of the various sedimentary sequences.

Sedimentation began with the initial deposition of fluvio-deltaic cross-bedded sands of Awi formation (Adeleye and Fayose, 1978) in early cretaceous times (probably Aptain). This was probably by the deposition of other formations in the area.

III. Method of Study

The study was carried out by the use of physical or megascopic description and identification of outcrops, structural features and minerals. Measurements of structural features were done with the aid of tape and compass clinometer while samples were collected with hammer and stored in sample bag; photographs of outcrops were also taken.

Field Equipment

1. Compass clinometers ,Hand lens ,Base map, Hammer, Measuring tape, photographic camera, Marking tape, sample bag
2. Hard cover field note book.

Field Mapping Parameters

The following are the parameters used in mapping the outcrops:

i. Dip: it is measured with the compass clinometers
ii. Strike: this is also measured with the clinometers

Others are:

iii. Direction of dip
iv. General trend of outcrop
v. Fracture trend
vi. Foliation trend
vii. Joint trend
viii. Vein trend
ix. Orientation of outcrops
x. Height of outcrops
xi. Length of outcrops
xii. Aerial extent of outcrop

IV. Geomorphology

Climate: Uyanga –Igbofia –Akamkpa-Awi-Calabar are all located in the tropics. The climate is tropical with seasonal rainfall and sunshine. The wet season is influenced by the rain bearing S.W trade winds which blows from March to November.

The sunny dry season is influenced by the N.E trade wind which blows across the Sahara desert for November to March.

Vegetation: The study area has very thick vegetation, inhibited by wildlife. The vegetation is the result of consistent rainfall which last almost all through the year.

Soil Erosion: The study area like most other parts of the Oban Massif and Calabar Flank has been highly eroded. The area is seriously affected by gully and sheet erosion. This has played a significant role in the rock arrangement outcrop pattern. The erosion can be attributed to the relief of the area which is undulating with few steep hills.

Relief: The area has an undulating relief with some area having steep mitts. These features are attributed to the intrusion of igneous bodies.

Drainage: The main drainage source is the Calabar River. All other tributaries drain into it. The area has a fairly good natural dendritic drainage system.

Fig. 2. Showing Vegetation of the study area.

V. Stratigraphy

Awi Formation: The Awi formation is sitting uncomformably on the basement complex rocks. They are the first cretaceous sediment in the area. The formation is made up of fluvio-deltaic clastic of early cretaceous (probably Aptian) age, accumulating in a prograding deltaic margin as deltaic and non-marine sediments.

Mfamosing Limestone: Enhanced subsistence of the faulted block resulted in the initiation of a series of marine transgressions. The earliest of such transgressions in mid-

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Albian times resulted in the deposition of platform carbonate i.e. Mfamosing limestone formation.

Odukpani Formation: This formation lies on the Mfamosing formation. It is a segment of thick highly fissile shale with minor but frequent intercalation of marls, calcareous mudstone and shell beds above. The base of this shale limit sequence is pyritic and rich in fish remains. It is late Albian to Cenomanian-Turonian in age. It is the Odukpani formation.

Ekenkpon shale Formation This formation is exposed at a road section in Ekenkpon village. It is a sequence of pyritic and organic rich sediments. Deposition of these sediments resulted from a second phase of marine transgression which was initiated in late Albian and continued through Turonian times, with a break towards the end of the Cenomanian.

VI. New Netim Marl Formation

This type section is found in New Netim. It is made up of impure limestone with some bioturbation. The outcrops are massive and there is evidence of solution.

Nkporo Shales are late Campanian to Maastrichtian sediments characterized by dark grey carbonaceous, friable shale's with occasional thin in ammonites and foraminifera data.

The Nporo Shales appear to have been deposited in a variety of environment including shallow open marine to paralic and continental settings.

Benin Formation

This formation consists mainly of sands and gravels with thickness ranging from 0 to 2,100 metres. The sands and sandstones are coarse to fine and commonly granular in texture and can be partly unconsolidated. The sediments represent upper deltaic plain deposits. The sands may represent braided stream point bars and channel fills. The shales are few and thin and they may represent black swamp deposits. Among the minor components are limonite coating, lignite streaks, haematite and feldspar.

VII. Geologic Features of Locations

Location 1

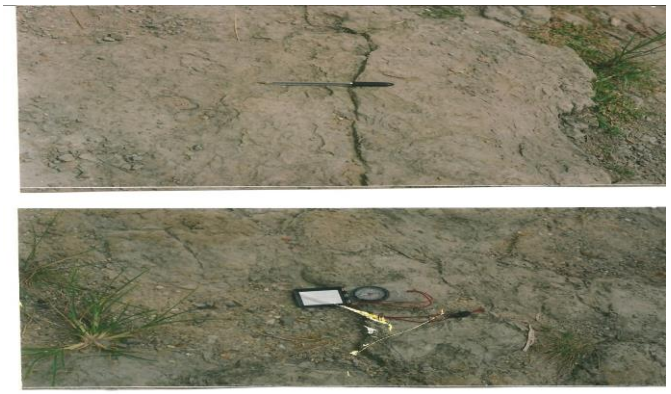
Situated along the Calabar –Odukpani Road; about few metres from the main road. The location's formation is Nkporo shales. The sediments are characterized by dark grey carbonaceous, friable fissile shale with occasional thin bands of marlstone and gypsum. The formation is rich in borrows and ammonite's foraminifera assemblages have also been formed in abundance in the formation (Edet and Nyong, 1994).

It is believed to have a late Campanian to Maastrichian age. The Nkporo shales appeared to have been deposited in a variety of environments including shallow open marine to paralic and continental settings.

Location 1 outcrop: Nkporo shale along with evidence of bio-turbation and burrow organism found at the mapped Area

Location 2

Situated along the Calabar–Odukpani, New Netim Road; about few metres from the main road. Marl outcrop described as the New Netim marls. These marl forms extensive ridge and consist of impure limestone (marl) and shale intercalations. They are highly burrowed and have been found to contain large quantities of ammonites. They also contain assemblages of echinoid.The marls are believed to have been deposited in a wide variety of near shore marginal marine settings.



Location 2 outcrop: New Netim marl srriking southern

Location 3

Situated along the Calabar–Odukpani Road about 2m away from the main road. The geologic feature found is a cave. The cave imbedded inside New Netin marls

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Caves are formed by various geologic processes. These may involves combination of chemical processes, erosion from water, tectonic forces, micro-organisms, pressure, atmospheric influences, and even digging.The cave in the study area is predominantly formed in limestone by dissolution. This type of cave is called solutional caves. Solutional cave are the most frequently occurring caves and such caves form in rock that is soluble, such as limestone, but can also form in other rocks, including chalk, dolomite marble, salt and gypsum. Rock is dissolved by natural acid in ground water that keeps through bedding-places, faults and so on. Over geological epochs cracks, and expand to become caves or cave systems.

How does the cave formed? Limestone dissolves under the action of rain water and groundwater charge with H_2Co_3 (carbonic acid) and groundwater occurring organic acid. The dissolution process produces a distinctive landform known as Karst, characterized by sinkholes and underground drainage.

Location 3 outcrop: Cave imbedded in new Netim marl

Location 4

The formation of location 4 outcrop is known to be Ekenkpon shale. This formation is exposed at a road section in Ekenkpon village. It is a sequence of pyritic and organic rich sediments. About 0.3m of shale formed the first bed at the top followed by 0.6m bed of limestone, then followed by massive intercalation of limestone and shale in the extend of about 15m, followed by shale of 10m extend of bed and lastly by limestone. The colour of limestone is reddish brown while that of shale is brownish in colour. The outcrop is trending E-W and dipping S.W. The paleoenvironment is likely to be marine.

Location 4 outcrop: Ekenkpon shale (limestone interbedded with shale) at the Ekenkpon village.

Location 5

Situated at some few kilometres from Awi main town. It is a type section of the Awi formation. It consists of a sequence of sandstone grading into siltstone with clay intercalations.

They are fluvio-deltaic and non-marine deposits of early cretaceous age. They mark the beginning of sedimentation in the Calabar Flank.

Location 5 outcrop: Top picture shows awl formation along Calabar-Odukpani Road & The picture under it shows the contact between sedimentary rock (awi formation) &The bedrock mapped at opposite side of the top outcrop in the same Area

Location 6

The outcrop of location 6 is located at some few kilometers from Ikom-Ita and about 5m from the main Calabar–Ikom road at Uyanga.

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It is a massive, strongly banded outcrop consisting of light and dark coloured minerals. The rock name is Biotite-gneiss; the gneisses are all quartz-feldspathic and medium to course grained. Foliations are present with are N-S to NE-SW (0-50^o) trending. Dips vary from 45^o -50^o towards 100^o -280^o respectively.

Location 6 outcrop: Top picture shows massive gneiss mapped along Uyanga- Akamkpa road and down picture shows quartz vein intrusion in gneiss in the same area

VIII. Metamorphic Geology

Metamorphism is defined as the process where rocks either sedimentary or igneous undergo structural, textural and mineralogical adjustment due to response to changes in temperature, presence and chemical environment which takes place at some depth.

In the map area, especially between Ikom-Ita and Igbofia, the granite gneiss, biotite gneiss and migmatic gneiss are all metamorphic products and have also undergone some form of metamorphism.

Gneiss

They are the dominant metamorphic rocks in the mapped area. They form the country or host rock in the area and are intruded by the granodiorite and strongly granitized in most places. They are strongly foliated and fractured and are medium to coarsed grained. They have N-S to NE-SW trending and dip steeply in most places where they have outcrop.

IX. Distribution Field Occurrence

The gneisses are the country rock and occur almost throughout the basement rocks in the area. There are outcrop in the Akamkpa, Ikom-Ita and Igbofia –Uyanga and the surrounding environment.

Petrology

The gneisses on the study area are strongly foliated and fractured. They contain xenoliths that are rich in biotite and hornblende. They are faulted and some are strongly baked.Along Ikom-Ita, the gneisses are shown to consist of metasediments of shale greywacke composition (Ekwueme and Onyeagocha 1986).The gneisses are basically kyanite gnesis biotite-horinblende and migmatite gneisses. They are medium to coarse grained.

Petrogneiss

The gneisses are believed to be product of the tectonic events that affected the Nigerian basement complex. These tectonic events are associated with the opening of the smith Atlantic and are believed to be Eburnean and pan African in age. They formed the country rocks in the study area.

Quartzite

Most of the quartzite is seen as veins. They are metamorphosed sandstone. It is likely that they are infilling of fractures which where later affected by heat produced by intruding igneous body. They are non-foliated and are also fractured.

X. Igneous Activity

Evidence from field relationships and mineralogy of the rock limits suggest that at least three cycles of igneous activities occurred in the basement complex and the Oban Massif was also affected.

The presence of meta-igneous rocks (granite gneiss, biotite-gneiss), biotite granite, dolerite and andesitic intrusions attest to this fact.

Granodiorite Intrusions

They are the most abundant igneous bodies in the study area. They occurs as large plutons with a general orientation N-S to NE-SW. In the Igbofia-Uyanga area, the outcrop occurs as large plutons. The rock is dark grey, massive weakly foliated, medium to coarse-grained. Contains 10 to 35 percent mafic mineral. Large K-feldspar crystals (up to 5.5 x 3cm) occur in the outcrop.The feldspar stands out in relief and appears to be preferentially orientated in the NW-SE direction.

They contain lens-shape xenoliths and schist which suggest that it was possibly emplaced through a stopping mechanism. It has a sharp contact relationship with the country rocks (schists and gneiss). The rock is fractured and ex-foliated has affected most of the outcrops.

The granodiorites in these areas enclosed mappable bodies of pegmatite which are rich in tourmaline.

Quartz Veins

Most of them occur as in fill of fractures in the granodiorites of gneiss. They are distributed all over the intrusion. A possible explanation of their occurrence might be that as the granodiorite intrusion occurs, fracturing of the

gneissic country rocks also occurs. These fractures were later filled by the quartz.

It might also be that the granodiorite was also affected by some later tectonic event which created fractures and faults which were later filled by the quartz to produce the quartz veins.

XI. Economic Geology & Hydrogeology

The study area has been affected by igneous and metamorphic processes as well as the deposition of the cretaceous sediments. The mineralization accompanying igneous and metamorphic activities as well as the sedimentary processes has given the area a high economic prospects.

Quartz

There are so many quartz veins that can be economically mined. They are of economic importance in the metallurgical industries, and in making sand papers, glass, gemstone and as quartz wedge used for finding the interference colour in minerals.

Feldspars

The amount of feldspar present in the study area is also economical and this can be mined for use in the ceramic industry

Biotite and Muscovite

Some of the pegmatite veins show high concentration of biotite and muscovite. They also important economically especially in making insulators.

Limestones

Most of the marls and limestone occurring in the industry can be mined and used in the cement industries and other allied industries.

Construction Materials Granodiorites

The granodiorites intrusions are quarried for road and other construction purposes.

XII. Water Resources

Though the basement rocks being crystalline do not allow water to penetrate through it, several seepages occur at the interfaces with the cretaceous sediments.

There are also network of streams which acts as source of water for both domestic industrial and agricultural purposes. The presence of thick cretaceous sediments in the Calabar Flank has of prospect of containing good aquifers.

XIII. Geologic History of the Area

The study areas have a heterogeneous geology. The Oban massif is affected by metamorphic and igneous activities while the Calabar Flank is basically composed of cretaceous sediments.

The study area (Odukpani-Ekpekpon-Awi-Uyanga-Igbofia-Calabar) are all partly of the Oban Massif and Calabar Flank.The Oban Massif consists of Precambrian basement complex overlain by the cretaceous tertiary sediments of the Calabar Flank. The Oban Massif which is Precambrian in age is a zone of regional metamorphic caused by volcanization.

The Oban Massif affected by the pan African orogeny. This is evident in the N-S, NE-SW orientation of the rocks.

Geochronological studies of the Oban Massif undertaken by Ekwueme and his co-workers confirmed that the Oban Massif belong to the Precambrian basement complex of Nigeria. The oldest rocks in the Oban Massif are banded gneiss (Ekwueme, 1994). The Calabar Flank is that part of the Southern Nigerian sedimentary basin that is bounded by the Oban Massif to the Northern the Calabar hinge line delineating the Niger Delta basin in the South. Its origin is intimately associated with the development of the Benue rift system. After the initial rifting episode, this area underwent a somewhat different tectonic and stratigraphic development compared to the adjacent Anambra and Southern Benue through sedimentary basin. The initial rifting of the Southern Nigerian margin produced two principal sets of faults, NE-SW and NW-SE system. The former set of faults bond the Benue depression, while the latter sets were more prominent and active in the Calabar Flank.

Murat (1972) describes the geologic history of the Southern Nigeria basin in terms of three major tectonic cycles which significantly controls the stratigraphic development of the basins. Two of these cycles are recognizable in the Calabar flank.

The area was faulted and affected by both marine transgressions and regressions with the deposition of the various formations,from the field relationship, it is obvious that the study area has undergone several tectonic episodes and the area is overlain by the cretaceous sediments of the Calabar Flank.

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