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# A TECTONIC IMPLICATION OF THE ERUPTION OF PYROCLASTICS IN UTURU, SOUTHERN BENUE TROUGH, SOUTHEAST NIGERIA

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## ABSTRACT

The origin of the Benue Trough is linked to rifting associated with the separation of South America from Africa in the Cretaceous times. The vast igneous activities in the trough are thought to either precede the separation of the two continents or post-date Albian sediments deposited in the trough after the separation. Exposures of pyroclastics within flatland in Uturu, east of Okigwe, were studied with a view to determining the implication of the eruption that emplaced the pyroclastics on the tectonic evolution of the Lower Benue Trough. Field expressions show that the pyroclastics erupted parallel to the axial plane of the Abakiliki anticlinorium in NE-SW direction and are spatially associated with shales of the Asu River Group and Nkporo Shale. Mud fragments of diverse sizes (1cm-20cm) and shapes of the host Asu River Group are incorporated in the pyroclastics. The sizes of the fragments of the pyroclastics fall mainly within the range of tuff and lapilli composed of mainly pyroxene, plagioclase, melilite and opaque minerals. The Nkporo Shales form cover unit over the pyroclastics and do not show any effect of the volcanism on them. The stratigraphic relationship between the pyroclastics and the surrounding sedimentary units shows that the pyroclastics erupted after the deposition of Asu River Group shales (mid-Albian) but terminated before the deposition of the Nkporo Shales. This corresponds to period between Cenomanian and Santonian and suggests a link to the tectonic events that post-dated the separation of South America from Africa.

**KEYWORDS:** Benue Trough, Tectonism, Abakiliki anticlinorium, pyroclastics, lapilli.

## INTRODUCTION

The origin and evolution of the Benue Trough are believed to be related to an aulacogen (Olade, 1975) or rift formed during the separation of South America from Africa in the Cretaceous (Okereke, 1988; Okeke et al. 1988; Freeth, 1990; Nwachukwu, 1990). Benkhelil (1989) was of the view that transcurrent faulting through an axial fault system, which developed local compressional and tensional regimes that resulted in basins and basement horsts, controlled the tectonic evolution of the Benue Trough. Benkhelil (1989) further posited that magmatism in the Cretaceous times was restricted to main fault zones in most of the trough, especially in the Abakaliki Trough, where it has alkaline affinities. However, in general, these igneous activities are thought to either precede the separation of South America from Africa (Uzuakpunwa, 1974; Ekwueme, 1994; Olade, 1979; Amajor and Ofoegbu, 1988) or post-date Albian sediments in the trough.

A study of one of the igneous activities at Uturu, 8km east of Okigwe, within the foot of the Okigwe-Awgu escarpment in the Lower Benue Trough was undertaken. Literature indicates that four lithologic units of Cretaceous ages have been recognized in Uturu (Simpson, 1955; Reyment, 1965), with the marine shale of the Asu River Group forming the oldest unit and the Ajali Sandstone, the youngest unit. The Santonian tectonism appears to have been accompanied by development of major faults and spates of volcanic activities (Hoque, 1980). Among the products of the volcanic activities are pyroclastics, which are associated with the Cretaceous sedimentary series, where the Nkporo Shale oversteps the Asu River Group unconformably. Pyroclastics are known to be important constituents of vapour-rich magma phases, and their eruption usually gives rise to a variety of fragments.

The pyroclastics outcrop in three low hills in Amanyanwu village of Uturu (Fig. 1), covering a total area of about 22,000m$^2$, and trend in a NE-SW direction, parallel to the Abakiliki anticlinorium (Fig. 1). The area forms an uneven relief, with the pyroclastic hills showing pronounced erosional features that impact smooth surfaces, devoid of thick vegetation, to the rocks (Fig. 2) and separated by low-lying Nkporo Shale. Lying at the foot of these pyroclastic bodies are ferruginous sands and dislodged boulders of the pyroclastics. Amajor et al. (1988) interpreted the Uturu pyroclastics as intra-continental plate alkaline basaltic volcanic rocks. This research is an attempt to use the mode of field occurrence, mineral paragenesis and textural characteristics deduced from petrography to suggest a regional tectonic model for the Lower Benue Trough.

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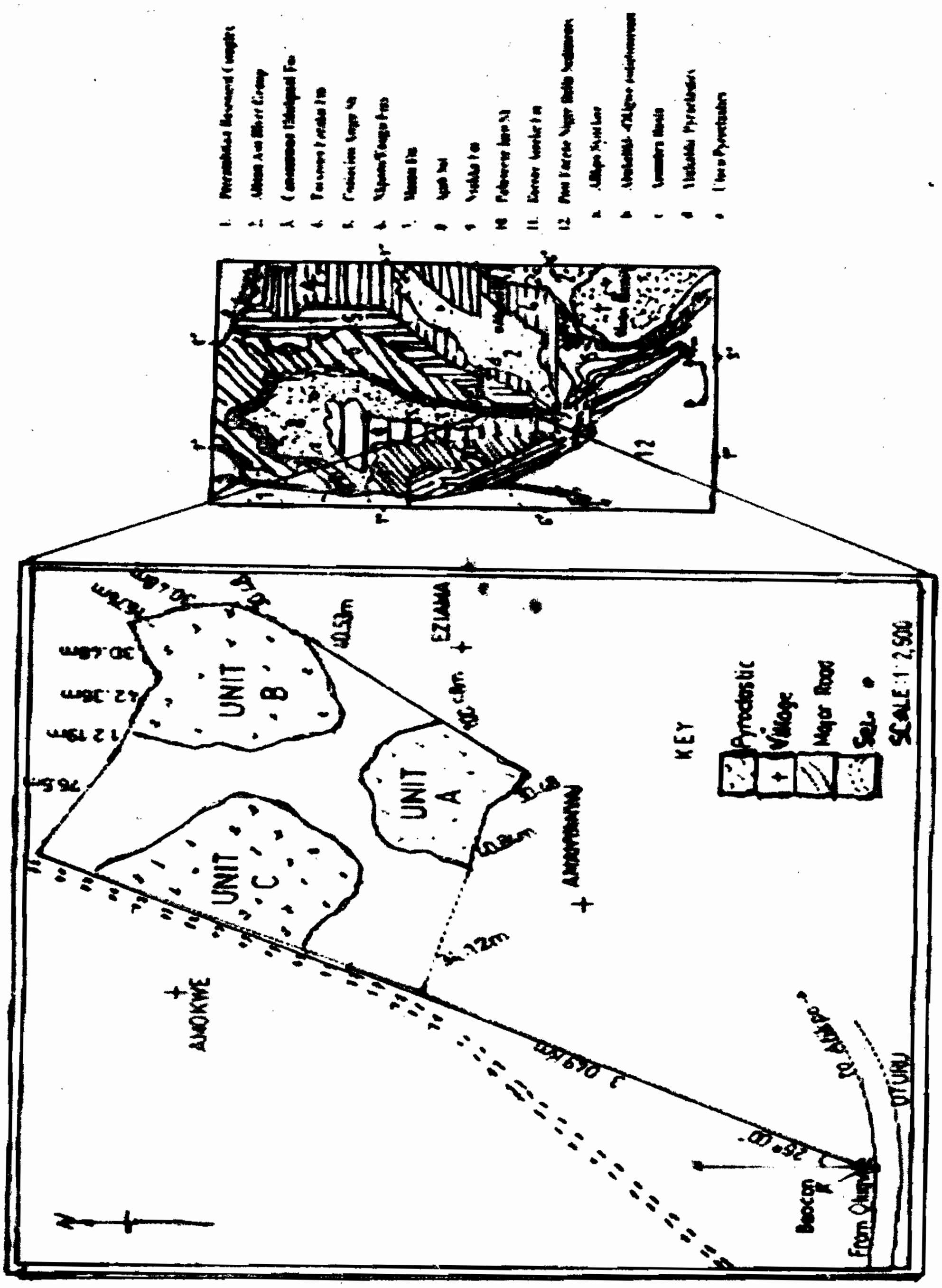


**Fig. 1:** Geologic map of the Study area showing the outcrops of the pyroclastics at Uturu. Inset: Geologic map of part of southeastern Nigeria showing the Abakiliki anticlinorium (adopted from Amajor and Ofoegbu, 1988).

## METHOD OF STUDY

Field studies of three units of the pyroclastics were undertaken to evaluate their spatial expressions such as aerial extent, exposed sections, contact relationships, structural trends and some special features like sizes and shapes of fragments. Samples were randomly collected vertically and across the exposures for microscopic studies to determine their mineralogy and textures in order to properly classify them and infer their petrogenetic and geothermal characters.

## RESULTS AND ANALYSIS

### Field Relations

The three units are essentially similar in mineralogy, texture, contact relationship and layering pattern. There are also other smaller units scattered around and between these principal units. The pyroclastics intruded the Asu River Group but are overlain in some parts by Nkporo Shale. Mamu and Ajali Formations are not associated with the pyroclastics. The Asu River Group, through which the pyroclastics extruded, is low-lying. The pyroclastics form maximum relief of up 7m above the flatland of Nkporo shales. Excellent exposures of the pyroiclastics are displayed by massive quarry activities in the area. There are some distinctive layers from base to top (Fig. 3) and alternation of thick (0.75-1.5m) and thin (about 0.15m) layers in all the three locations of 7,500m$^2$, 8,438m$^2$ and 6,250m$^2$, respectively. When fresh, the rocks are greenish to dark colour and light to brownish colour when weathered. Large rounded, spindle-shaped fragments (agglomerate bombs) of the pyroclastics are embedded in fine matrix components.

**Mineral Composition**

Mineralogy of the pyroclastics is uniform. In thin section, the constituent minerals are mainly euhedral pyroxene (augite), plagioclase and melilite. Quartz, pyroxene, plagioclase and melilite occur as phenocrysts The groundmass minerals show interference colours from colourless to dark-grey, blue or brown, and are also largely pyroxene, plagioclase and melilite. Opaque minerals are present in varying amounts.

**Fragments and Textures**

Pyroclastics in the Benue Trough have been variously described as pyroclastic flows, breccias, tuffs, agglomerates (Okezie, 1965; Uzuakpunwa, 1974 and Olade, 1979). Field studies indicate that all the fragments are highly angular except for a few agglomerate bombs in matrix of tuff or lapilli. Thus, most of the fragments appear to have been emplaced in solid condition. There are a few blocks of older rock components of sedimentary origin, whereas majority of the fragments fall under lapilli size. Thus, the pyroclastics are principally composed of lapilli breccia. Some few sections are composed of entirely volcanic tuff. In some places, lapilli are moderately scattered in the tuff to form lapilli-tuff. The Uturu pyroclastics compare with the Abakiliki pyroclastics described by Olade (1979). Most of the large fragments are mixtures of both angular and rounded fragments (Fig. 4). Some of the fragments show chilled margins (Fig. 5), while the vitric tuff shows vitroclastic texture (Fig 6) Vesicles are common features of most parts of the pyroclastics

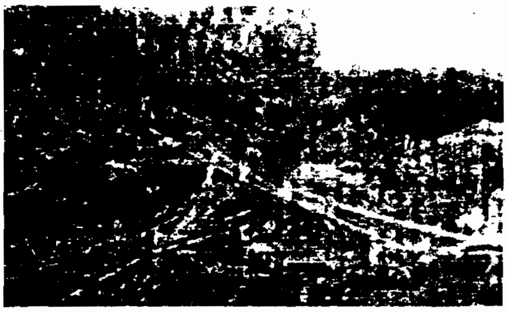

Fig.2. Sparse vegetation within the pyroclastic bodies

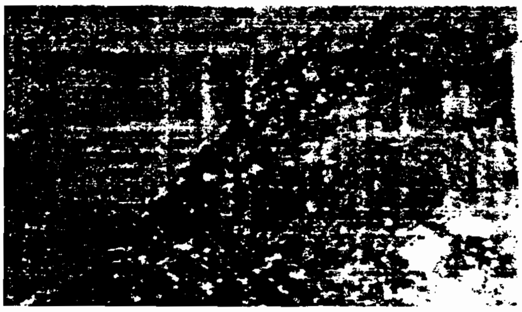

Fig 5. Chilled margin between layers of the pyroclastics rich in volcanic bombs and breccia

Fig.3. The pyroclastics showing well defined layering

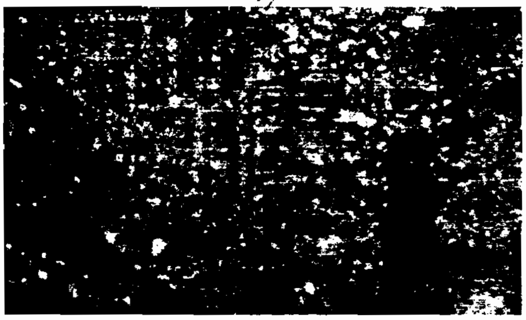

Fig.6. Vitric textures of the pyroclastics in the Study Area

Fig.4. Porphyritic textures of the pyroclastics in the Study Area

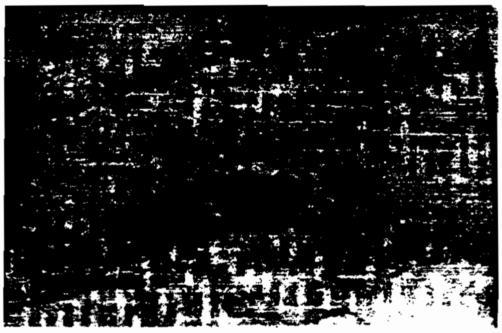

Fig.7. Shaly fragment of the older Asu River Group in the pyroclastics.

## GEOTECTONIC IMPLICATIONS

Earlier workers relate the origin of the Benue Trough to the separation of South American continent from the African continent in early Cretaceous (Burke *et al.* 1971; Wright, 1981). Many scholars believe that South America finally separated from Africa in Santonian times and that the high level tectonic activities that occurred in Santonian times may be related to the separation of these two continents (Wright, 1968, 1972; Burke *et al.* 1971; Nwachukwu, 1972; Hoque, 1980). The swinging back of Africa due to the final separation from South America formed compression zones, which may have been responsible for the intense folding, faulting and volcanism in the Benue Trough, during the Santonian times (Ekwueme, 1994). Burke and Whiteman (1973) believed that the magmatism in the Benue Trough was andesitic due to sea floor spreading.

The basaltic mineral compositions of mainly pyroxene, plagioclase and melilite, and the dominance of fine to glassy texture and eruption along the axis of the Abakiliki anticlinorium suggest deep-seated source, which exploited the fissures created by the Cenomanian or Santonian tectonism resulting from separation of South America from Africa in the Cretaceous times (Beka and Ukaegbu, 2006). The interactions of these two continents may have resulted to fluid accumulation in the axis of their stress field, along the Abakiliki Anticlinorium, giving rise to explosive eruption of the magma from beneath. Thus, the pyroclastics appear to be products of widespread tectonism, which accompanied the separation of South America from Africa. However, the pyroclastics do not show any evidence of tectonic deformation

The pyroclastics seem to be controlled by the NE-SW trending axis of the Abakiliki Anticlinorium, suggesting that the Santonian (or earlier Cenomanian) tectonic event might have formed a fracture system that trends parallel to the axis of the Abakiliki Anticlinorium, in the Benue Trough. This evidence is collaborated by Hoque (1984), who said, "the pyroclastics are much younger (late Santonian) than the Benue Trough (early Cretaceous)". The fracture system may have provided the pathway for the magma that eventually erupted explosively due to huge accumulated gas phase. If the extrusion was consequent to the Cenomanian or Santonian event, then it explains the presence of near-vertical aligned mud rocks of the pre-Santonian shale of the Asu River Group in the pyroclastics. The time of the magmatism can be deduced from the stratigraphic relationship between the pyroclastics and surrounding sedimentary sequences (Table 1). Since the Asu River Group (Albian) is older than the pyroclastics as supported by inclusions of its fragments in the pyroclastics (Fig.7), and, on the other hand, the pyroclastics are older than the overlying Nkporo Shale (Campo-Maastitchian), then the pyroclastics were emplaced between the Albian and Campanian times However, because there were two tectonic episodes between the Albian and Campanian times (Reyment, 1965; Nwachukwu, 1972; Uzuakpunwa, 1974; Olade. 1975), the eruption could have taken place during one of these two events.

## CONCLUSION

Petrological investigation revealed basaltic source, dominated by pyroxene, plagioclase, melilite and opaque minerals and the pyroclastics show primary structures such as xenoliths of mud rocks derived from the older shales of the Asu River Group, and parallel layering. The stratigraphic relationship between the pyroclastics and the surrounding shales of the Asu River Group suggests a post-Albian but pre-Campanian age for the pyroclastics. The eruption may be related to the separation of South America from Africa. The interactions of these two continents may have resulted to fluid accumulation in the axis of their stress field, parallel to the axis of the Abakiliki Anticlinorium, resulting in explosive eruption of the magma from beneath. The swinging back of Africa due to the final separation from South America formed compression zones, which may have been responsible for the intense folding, faulting and volcanism in the Benue Trough, during the Santonian times.

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