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Crystallization Paths of Basaltic Rocks in Afikpo Basin Southern Benue Trough, Nigeria

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Abstract

The crystallization paths of basaltic magma have been studied using the basaltic rocks (e.g. gabbro, dolerites and basalts) that occur in Ameta, Mgbom and Ozaraukwu areas in southeast Nigeria. Regional mapping and petrography show that the basaltic magma in Ameta crystallizes to form gabbro. The mineral paragenesis in the gabbro is plagioclase + olivine + pyroxene + hornblende + biotite ± quartz. However, in Mgbom, the magma crystallizes as dolerites. In thin sections, the dolerites consist of plagioclase, olivine, pyroxene, and biotite. Paths of tectonism extended up to Ozaraukwu where the magma crystallized as dolerites and basalts that occur as a dyke in the sedimentary sequence of the area. The basalt consists of plagioclase, olivine, pyroxene, biotite, while quartz occur as accessory mineral. The variable concentrations of the minerals and their pattern of emplacement depict that magmatic differentiation, assimilation and contamination played major roles in the evolutionary history of magmatic rocks in the study area.

Keywords: Basaltic rocks; Crystallization paths; Benue trough; Afikpo basin

Introduction

The study area is in Afikpo Basin which is on the eastern flank of the southern Benue Trough. The Benue Trough was formed as a result of tectonism that resulted to the separation of South America from Africa during the Cretaceous. The tectonism was accompanied by magmatism and the magmatic episodes led to the emplacement of the igneous rocks in the study area. The magmatism that occurred in the southern Benue Trough is characterized by alkaline and subalkaline rocks [1-3]. Magma is characterized by their constituent elements [4] and this makes it imperative that the petrography of the rocks should be studied in order to determine the mineral constituents of the rocks and the paths of crystallization. Magmatism in Benue Trough has been studied and documented by many authors [1,3,5-7].

However, not much has been written on the crystallization paths of the magmatic rocks in Afikpo Basin. The present study aims to unravel the path of crystallization that has taken place in the study area (Figure 1).

Geological Setting

The Afikpo Basin is located in the eastern flanks of the Benue Trough. The basaltic rocks form topographic highs in the sedimentary sequence of Ameta, Mgbom and Ozaraukwu. The area consists of Asu River Group and Eze-Aku Shales. According to Odigi and Amajor [8], Afikpo Basin is made up of Albian, Turonian-Coniacian and Campanian-Maastrichtian sediments and spans well over 2500km^2.The basaltic rocks intruded the oldest sediment (Asu River Group).

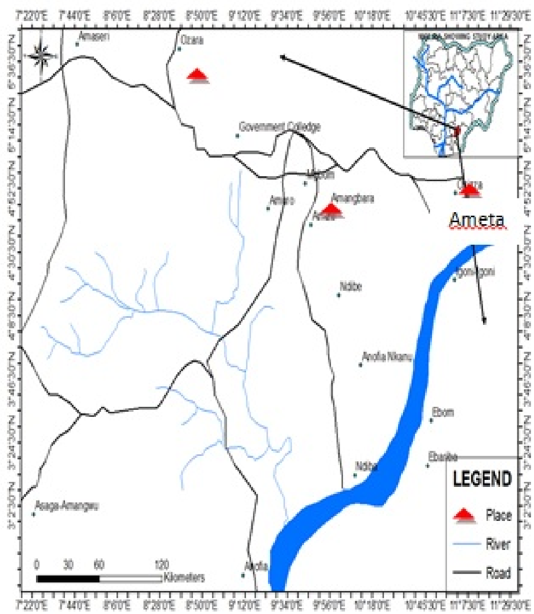

Figure 1: Map of the study area.

Sampling Methods

Twelve representative samples of dolerites, six samples of basalt, and twelve samples of gabbros were collected from different pockets at Ameta, Mgbom and Ozaraukwu quarry (Figure 2). The representative

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portions of samples of the studied rocks were used to prepare the thin sections. Samples for thin sectioning were trimmed using cutting machine and the trimmed samples were polished to reduce the thickness to 0.03 mm as to allow light to penetrate through during the optical interpretation of the component minerals. The interpretation of the thin sections employed the use of petrological microscope.

Figure 2: A. Gabbro at Ameta; **B.** Gabbro at Ameta.

Petrology and Petrography

The basalts in Ozaraukwu are aphinitic in texture, and have a sharp contact relationship with the dolerites. The mineral compositions of the basalts are plagioclase (55%), olivine (20%), pyroxene (15%), biotite (10%) (Figure 3), while dolerites at Ozaraukwu contain plagioclase (50%), olivine (10%), pyroxene (25%), biotite (10%), quartz (4%) (Figure 4). The dolerites at Mgbom contain plagioclase (55%), olivine (20%), pyroxene (10%), biotite (5%), hornblende (5%), quartz (4%) (Figure 5). The dolerites occur as dyke and are melanocratic in colour, have phaneritic textures and composed of phenocrysts of biotites. The average mineral compositions in the gabbros are plagioclase (50%), olivine (15%), pyroxene (20%), hornblende (2%), biotite (8%), quartz (3%) (Figure 6). Plagioclase shows albite twinning, olivine shows pale green colour to pleochroic colour of brownish black. The pyroxene exhibit dark green to pleochroic black colour and also exhibit prismatic cleavage. Under transmitted light, the biotite shows brown to black colour and also exhibit euhedral crystal form.

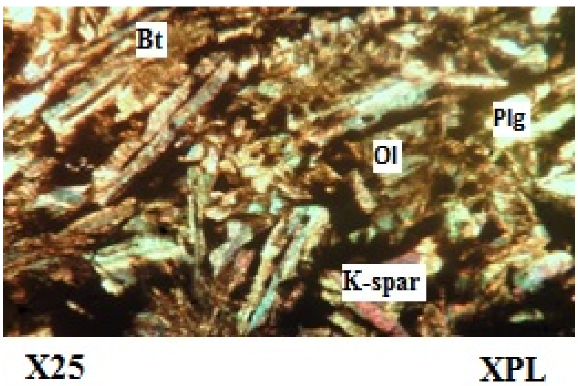

Figure 3: Mineral compositions of the basalt at Ozaraukwu. Note: Ol = Olivine, Plg = plagioclase, Bt = Biotite, k-spar = potassium feldspar.

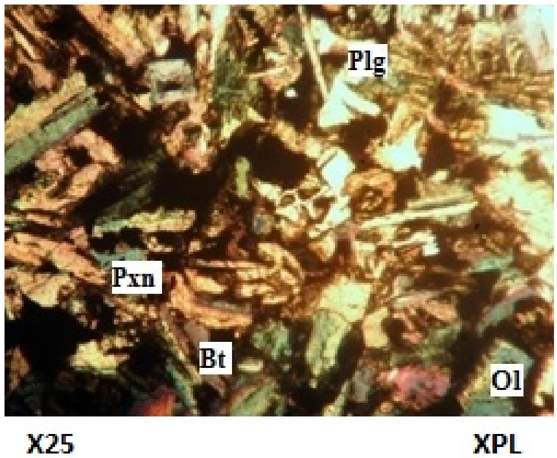

Figure 4: Mineral compositions in the dolerite from Ozaraukwu. Note: Ol = Olivine, Plg = plagioclase, Bt = Biotite, Pxn = pyroxene.

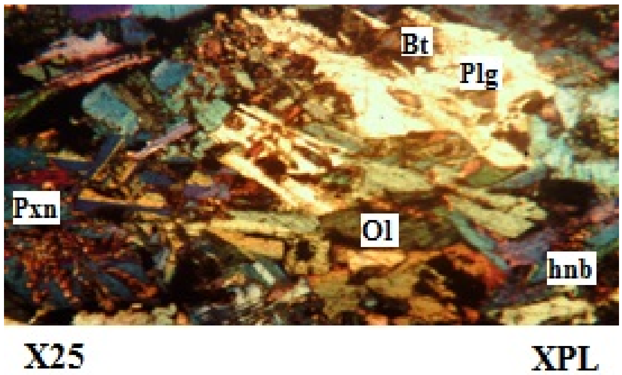

Figure 5: Mineral compositions of the dolerite at mgbom. Note: Ol = Olivine, Plg = Plagioclase, Bt = Biotite, Pxn = pyroxene, hnb = Hornblende.

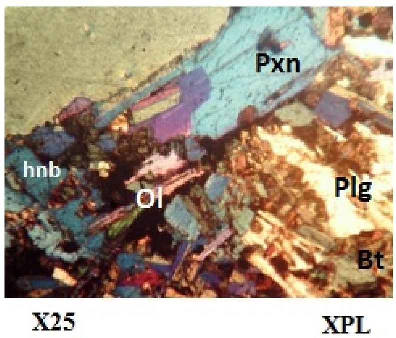

Figure 6: Mineral compositions in the gabbro from Ameta. Note: Ol = Olivine, Plg = plagioclase, Bt = Biotite, Pxn = pyroxene, hnb = hornblende.

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Petrogenesis and Geotectonic Setting

The most recent tectonic activity is the Pan-African [9]. The tectonic episodes were accompanied by magmatism which led to the formation of the igneous rocks in the areas. The geology of the Benue Trough has been documented by Peters and Ekweozor [10], Okeke et al. [11], Onwualu-John and Ukaegbu [3,12].

The petrology and petrography indicate that partial melting and fractional crystallization of mantle formed the magma, and it is important to note that ocean floor basalts originate only from the mantle. The mineral paragenesis of the rocks is typical of fractional crystallization of the mantle. The presence of high temperature minerals (olivine, pyroxene and plagioclase) depicts that the study areas were high temperature tectonic active zones. The degree of partial melting and high pressure probably contributed to the silica under saturated nature of the rocks. Progressive partial melting could be the reason for the compositional variation in the rocks.

Discussions

The tectonism in the Benue Trough was accompanied by magmatism. The tectonism probably generated satellite rift through which magma erupted at diverse areas in the Afikpo Basin. In Ameta, basaltic magma gave rise to the gabbroic rocks; probably the crystallization of the magma closed the vent through which the magma erupted thereby giving much time for the basaltic magma to cool. At Mgbom, the eruption of basaltic magmagave rise to crystallization of rocks at shallow depth. Mgbom hosts some dolerites (Figure 7). Probably due to the low viscosity of basaltic magma, the magma migrated or extended across a large distance. The magmatism extended to Ozaraukwu where the magma erupted at shallow depth and also occur as lava (Figure 8). There is co-existence of dolerites and basalts in Ozaraukwu (Figure 9). The occurrence of the basalt in the suite could be as a result of pressure increase in the magmatic chamber or increase in tectonic activity which probably created lateral fissures. Every tectonic environment host basalts [13]. This evolutionary trend in the igneous suite results to varying physio-chemical characteristics in the rocks.

Figure 7: Dolerite outcrop in Mgbom.

Figure 8: A. Dolerite outcrop in Ozaraukwu. **B.** Basalt outcrop in Ozaraukwu.

Figure 9: A. Coexistence of basalt and dolerite at Ozaraukwu. **B.** Coexistence of basalt and dolerite at Ozaraukwu.

As the magma migrates to Mgbom and Ameta, the thermal effect reduced. To that extent, it also appears that a fractionating magma erupted at Mgbom, Ameta and could be the reasons for the variation in mineral percentages of the basaltic rocks (Table 1). The crystallization features show that the basaltic magma in Ameta experienced slow rate of cooling which reflects the texture of the gabbroic rocks and occurrence of some megascopic minerals (biotite, olivine). It seems that the eruption started at Ozaraukwu and the dolerites and basalts in the suite are formed from primary magma at the early part of the magmatic eruption.

Mineral	Ozaraukwu Basalt	Ozaraukwu Dolerite	Mgbom Dolerite	Ameta Gabbro
Plagioclase	55	50	55	50
Olivine	20	10	20	15
pyroxene	15	25	10	20
Biotite	10	10	5	8
Hornblende	-	-	5	2
Quartz		4	4	3
Total	100	99	99	98

Table 1: Modal composition values of the rocks.

The nature of the occurrence of the rocks depicts the pattern of eruption (central eruption and fissure eruption) in the study area. Batch melting also played role in the evolution of the rocks in the study areas. Coulon et al. [2] documented the magmatic episodes of Benue

Trough as first and second episodes of magmatism (first episode of magmatismis located in the early Cretaceous core of the Abakaliki Anticlinorium and second episodes of magmatism is associated with the upper Cretaceous Anambra and Afikpo basins). The eruption of magma in batches or episodes in a tectonic zone can cause variation in the mineralogical and physical features of the same types of rocks in a tectonic province.

Conclusion

The eruption of basaltic magma in Ameta, Mgbom and Ozaraukwu suggests that the magmatism in these areas probably started from Ozaraukwu. The igneous suite in Ozaraukwu is very massive which is a signature of central magmatic eruption which generated some lateral fissures. The rocks in Ozaraukwu are deficient in quartz. The absence of quartz in the igneous suite shows that the rocks crystallized from primary magma with limited contaminations.

The field occurrence of the dolerites in Mgbom shows slow rate of crystallization which conforms to non-explosive eruption of the magma. Tectonic movement, decrease in the thermal condition and high mobility of the basaltic magma probably contributed to the formation of gabbro at Ameta. The mode of emplacement of the gabbros and the phaneritic texture of the gabbros is an indication of slow pattern of crystallization. The study area can be classified as one of the tectonic-prone zones during the Pan African thermo-tectonic events.

References

1. Amajor LC, Ofoegbu CO (1988) Intra-Continental-Plate Alkaline Basaltic Volcanism, Uturu Southern Benue Trough, Nigeria. Acta Universitatis Carolinae-Geologica 2: 233-242.
2. Coulon C, Vidal F, Dupuy C, Baudin F, Popoff M, et al. (1996) The Mesozoic to Early Cenozoic Magmatism of the Benue Trough (Nigeria); Geochemical Evidence for the Involvement of the St Helena Plume. J Petrol 37: 1341-1358.
3. Onwualu-John JN, Ukaegbu VU (2009) Geochemistry of the association of syenodiorites and pyroclastics in the Southern Benue Trough, Nigeria: Petrogenetic and Tectonic implications. World J Appl Sci Technol 1: 11-27.
4. O'Hara MJ (1965) Importance of the 'shape' of the melting regime during partial melting of the mantle. Nature 314: 58-62.
5. Uzuakpunwa AB (1974) The Abakiliki pyroclastics-Eastern Nigeria: new age and tectonic implications. Geological Magazine 111: 65-69.
6. Offodile ME (1976) The geology of the middle Benue. Nigeria: Paleontological Institute, University Uppsala, Special Publication 4: 1-166.
7. Onwualu-Joh JN, Okengwu KO (2016) Petrographic and Geochemical Evaluation of Some Mafic Rocks in the Southern Benue Trough Southeatern Nigeria. Geochem J 3: 1-5.
8. Odigi MI, Amajor LC (2009) Brittle Deformation in the Afikpo Basin, Southern Nigeria: Evidence for a Terminal Cretaceous extensional regime in the Lower Benue Trough, Nigeria. Chin J Geochem 28: 369-376.
9. Ekwueme BN (1994) Basaltic magmatism related to the early stages of rifting along the Benue Trough: The Obudu dolerites and pyroclastics of south-east Nigeria. Geol J 29: 269-276.
10. Petters SW, Ekweozor CM (1982) Petroleum Geology of Benue Trough and Southeastern Chad Basin, Nigeria: Geologic Notes. AAPG Bulletin 66: 1141-1149.
11. Okeke PO, Ofoegbu CO, Amajor LC (1988) On the origin of the highly altered basalts, Southern Benue Trough, Nigeria. Bulgarian Academy of Sciences. Geochemistry, Mineralogy and Petrology 24: 55-67.
12. Onwualu -John JN, Ukaegbu VU (2010) Alkaline Magmatism in the Lower Benue Trough, Southeastern Nigeria: A Geochemical Evaluation. IUP J Earth Sci 4: 23-48.
13. Hall A (1987) Igneous Petrology.