Journal of Earth Sciences and Geotechnical Engineering, vol.6, no. 3, 2016, 177-183
ISSN: 1792-9040 (print version), 1792-9660 (online)
Scienpress Ltd, 2016

Petro genetic Relationship of the Basaltic Rocks in Ugwukwu, Afikpo Basin, Southern Nigeria: Case of Basalts and Dolerites

Onwualu-John, Josephine N[1] and Samba Assomo P[2]

Abstract

The petrography of the basaltic rock in ugwukwu was studied in order to provide reliable information for their petrogenetic history. The petrographic results show that ugwukwu comprise of dolerite and basalt which intruded the oldest sediment in the area. The basaltic rocks (dolerites and basalts) occur as dyke. The mineral paragenesis of the dolerite is plagioclase+olivine+pyroxene+biotite with quartz as accessory mineral while the mineral paragenesis of the basalt is plagioclase+olivine+pyroxene+biotite+- quartz. The tectonism that occurred in the study area was accompanied by magmatism and this resulted to the emplacement of the igneous rocks. The mineral compositions in the rocks shows that the igneous suite in Ugwukwu are products of basaltic magma.

Keywords: Basaltic rocks, Dolerites, Petrogenesis, Ugwukwu.

1 Introduction

Benue Trough is a failed arm of the triple rifts that occurred in the Cretaceous when South America separated from Africa. The rift was as a result of tectonic episodes. The tectonism was accompanied with magmatism which resulted to the emplacement of igneous rocks in the area. The tectonism caused the deformation of the sedimentary sequences of the area. The Santonnian tectonism resulted to the formation of Abakaliki Anticlinorium. The Abakaliki Anticlinorium is made up of two synclinal basins (Afikpo basin on the east and Anambra basin on the west) on its flank [1]. Afikpo basin hosts some igneous rocks which are basaltic in nature.

[1] Department of Geology, University of Port Harcourt, Nigeria
[2] Department of Earth Science, University of Yaounde I

Magma are Characterized by their constituents element [2], the mineralogical compositions of the rocks depends on the minerals of the source region and the differentiating mechanisms of the magma. This research is to unravel the genetic relationship of the rocks in the igneous suite using their mineralogy and field associations.

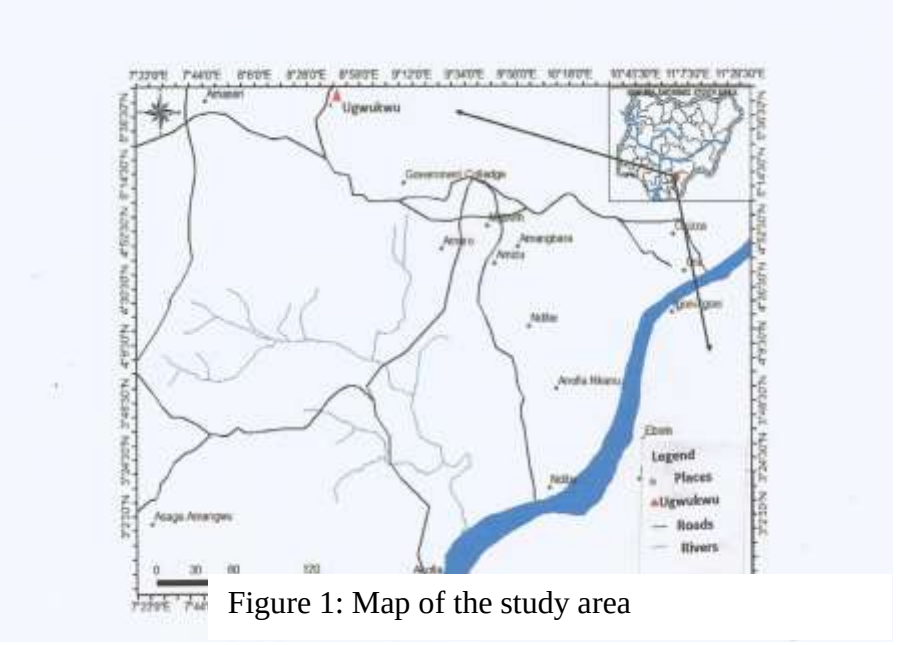


Figure 1: Map of the study area

2 Preliminary notes

2.1 Presentation of study area and geologic setting

Ugwukwu is within the Afikpo basin of southern Benue trough Nigeria. The basin extends from 7° 22’ 0’’ to 11° 29’ 30’’Long.E and from 5°36’30’’ to 3° 2’ 30’’Lat.N (Figure.1). The field relation are magmatic rocks(dolerites and basalts) which form topographic features in the sedimentary unit. The magmatic rocks occur as dykes in the sedimentary rocks of the study area. Basalt outcrop are adjacent to the dolerite and as well occur in extrusive form. The dolerites occur at shallow depth with some supra sediments overlying them. [3], state that Afikpo Basin is made up of Albian, Turonian-Coniacian and Campanian-Maastrichtian sediments and spans well over 2500km2.The basaltic rocks intruded the oldest sediment (Asu River Group).

2.2 Material and methods

Fresh rock samples were collected at different pockets at the quarry. The rocks are melanocratic in nature. The dolerites are medium to coarse grained while basalts are fine grained. Thin sections of the rock samples were trimmed using cutting machine. The trimmed samples and the slides were polished on a glass plate that contained mixture of carborundum and little water. The rocks were polished to 0.03mm as to allow light to light to penetrate it during microscopic interpretations. The interpretations employed the use of petrological microscope and were based on elemental compositions.

3 Results and interpretation

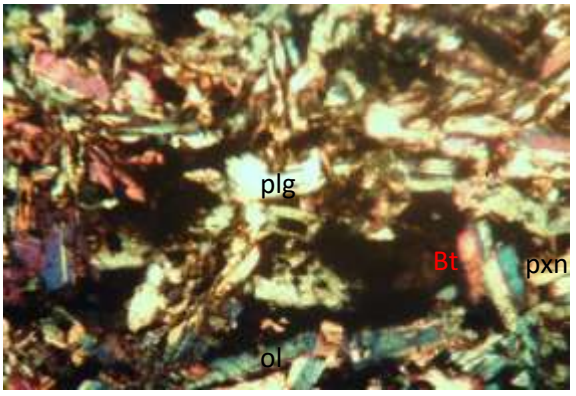
3.1 Mineralogy and Petrography

The thin section allows to determine the average mineral compositions of the rocks (Tab.1). Dolerites is composed by plagioclase (45%), olivine (20%), pyroxene (15%), iron oxide (5%), biotite (10%) and quartz (3%) (Figures 2 and 3) while Basalt is characterised by plagioclase (50%), olivine (25%), pyroxene 10%), biotite (5%), iron oxide (8%), quartz (2%) (Figures 4 and 5).

Table: 1 Mineralogical composition of the rocks
Plg=plagioclase, Pxn=pyroxene, Bt=Biotite, Ol=olivine Qz: quartz

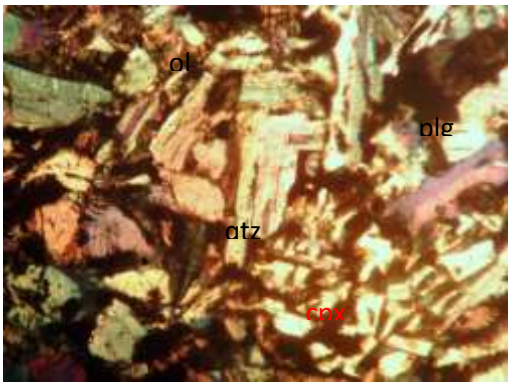
Rock Types	Plg	Ol	Pxn	Iron oxide	Bt	Qz	Total
Dolerits (%)	45	20	15	5	10	3	98
Basalts (%)	50	25	10	8	5	2	100

This composition indicates that the rocks were formed in the nearest condition from a single original material. The plagioclase in the rocks shows albite twinning, they show striated white colour with pleochroic dark colour. Olivine is pale green with pleochroic brown colour. Biotites in the rocks show subhedral form, brown in colour and pleochroic black colour. Pyroxene shows dark green to black pleochroic colour. The basalt is deficient of quartz and represents olivine basalt.



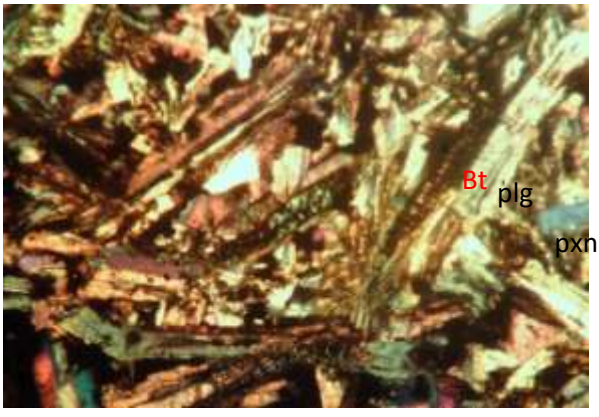
X 25 **XPL**

Figure 2: Photomicrograph showing the mineral compositions of the dolerite sample: plg=plagioclase, cpx=clinopyroxene, Bt=Biotite, ol=olivine



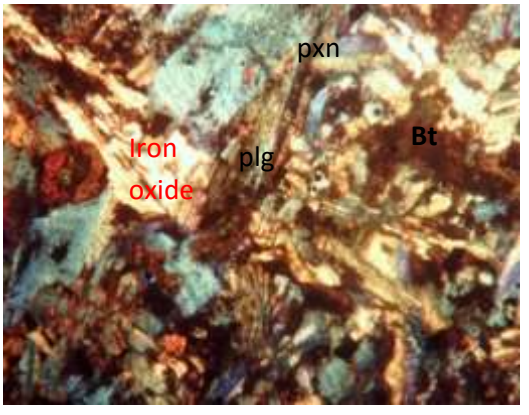
X 25 **XPL**

Figure 3: Photomicrograph showing the mineral compositions of the dolerite sample: plg=plagioclase, cpx=clinopyroxene, Bt=Biotite, ol=olivine



X25 **XPL**

Figure 4: Photomicrograph showing the mineral compositionsin the basalts sample: plg=plagioclase, pxn=pyroxene, Bt=Biotite, ol=olivine



X25 **XPL**

Figure 5: Photomicrograph showing the mineral compositions of plg=plagioclase, pxn=pyroxene, Bt=Biotite, iron oxide in the basalt sample.

3.2 Petrogenesis

Petrographic features of the rocks are typical of basaltic origin. Basaltic magma are less viscous and more mobile. The massive nature of the rocks confirms the extent to which the magma migrated. The association of dolerite and basalt in a suite confirms the spread of the magma during the evolutionary stage to the emplacement of the magma[4]. The occurrence of intrusives (dolerites) and extrusives (basalts) depicts the nature of the eruption and it also depends on the density control. The massive nature of the dolerites support central eruption of the magma. The tectonisms probably generated satellite rift through which the magma erupted to the surface as lava and crystallized to form the basalts. The field association of the rocks appear to be syn-genetic. The rocks occurring as dyke could be due to the less density of the magma which propels the magma to rise discordantly to the host rock.

The basalt and dolerites of the igneous suite are characterized mostly of mafic minerals which reflect to the colour the rocks. The presence of femic minerals (olivine, pyroxene, biotite) indicate that partial melting and fractionation of the mantle generated the magma. The mantle is believed to compose richly of olivine and pyroxene and these played vital roles in the mineralogical constituents of the basaltic rocks[4]. The high percentages of the plagioclase suggested that the basaltic magma probably contains plagioclase cumulate. The mechanisms of the emplacement of the rocks could be that magma rises and flows out into the volcano thereby crystallized as the dolerite. [5] showed that the satellite rift generated by the tectonism created channel for the lava and solidifies as basalt.

3.3 Geotectonic setting

Basaltic rocks show peculiar features to specific tectonic provinces. They are associated with divergent plate margin (ocean floor basalt, OFB), volcanic arc basalt, (VAB), oceanic island basalt (OIB), and within plate of continental crust [6] and [7]. Basaltic rocks of different tectonic environments do not have the same origin.

3.3.1 Primary origin of the basaltic rocks

Magma composed of the mineral and chemical constituents of the source region/material. The source rocks that melted to form basaltic magma should have basaltic compositions. Probably, partial melting of the peridodites gives rise to the basaltic magma. Perododites which contains clinopyroxene, olivine of high Fe/Mg ratio can be partially melted to yield a basic liquid [8]. The enrichment of the basaltic rocks with femic minerals (olivine, pyroxene) could be due to the partial melting of the peridodites as a source material.

3.3.2 Secondary origin of the basaltic rocks

Presence of phenocrysts of bioties is an indication of crystal fractionation in the magmatic evolution. Contamination of the magma can occur from the subduction of the oceanic crust into the magma and results to melting of the oceanic crust

which incorporates and becomes part of the source magma. The rising primary magma probably interacts with the continental crust during the migration; this could be the reason for the contamination of the primary magma with traces of quartz which were present in the rocks [5].

3.3.3 Geotectonic origin of the basaltic rocks

The basaltic rocks were derived from the mantle (ocean floor basalt and oceanic island basalt). These types of basaltic rocks are formed at divergent plate margin (MORB). The oceanic ridge basalt are believed to form from the partial melting of the mantle close to the spreading ridge. The origin and eruption of the magma from mantle, through a hotspot system in divergent setting show that the basaltic rocks from Ugwukwu are derived from a single parent source with the same source material [5].

3.4 Discussion of results

Many authors were interested by the study of the formation and the evolution of the magma [4], [5], [9], [10], [11], [12]. These studies were especially related to the reactional suite of the mineral that are built in accordance with the suitable stages of temperature and pressure during the magmatism process. [10] and [11] situated the crystallization of plagioclase at 1235°C and Olivine at 1268°C, the corresponding pressure extends from 10 Kb to 40 Kb. For [9] the pressure can be used to separate alkali basalt and tholeitic basalt. This author explains that the pressure in which tholeitic basalt is between 1040 Kb to 1230 Kb while alkali basalt is located in the interval of 1155 Kb – 1185 Kb. The study of geochemical evolution of the suite of mineral were introduced by [4] and gives the behaviour of major and trace elements during magmatism phenomena. All these authors agree to the fact that partial melting and crystal fractionation remains the major processes that control the formation and the evolution of the magma and the geotectonic context can play an important role during the dynamism of magma. The same observations were made in this paper. In contrary to the above researches, the study of petrogenetic relationship of the rocks in Ugwukwu is based only on the comparison of the mineralogy of basaltic rocks (intrusive and extrusive). From this mineralogy the relationship were established in many aspects. Also, the study of physics parameters as temperature and pressure were out of the aim of this research.

4 Conclusion

The ugwukwu basaltic rocks are derived from the mantle source which have encountered little or insignificant contamination from the continental crust. The field occurrence and mineralogical features of the rocks characterised magma

originating from partial melting of the mantle to the oceanic crust and eruption terminated at continental setting.

References

[1] C. Kogbe, The Cretaceous and Palaeogene sediments of southern Nigeria, Geology of Nigeria,C.A. Kogbe (ed.).Lagos: Elizabeth publishing Co, 1976.
[2] M. O'Hara , Importance of the 'shape' of the melting regime duringpartial melting of the mantle. Nature 314, (1965), 58-62.
[3] M. Odigi and L. A major 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, (2009), 369-376.
[4] Y.Panjasawatawong and W. Yaowannoiyothin, Petrochemical study of post-Triassicbasalts from the Nan suture, northem Thailand. Journal of Southeast Asian Earth Sciences, Vol 8, Issues 1-4, (1993), 147- 158.
[5] H. Szabolcs, S.Tama, S Loan, T. Ntaflos, Origins of magma of persani volcanic field, Komawa: A combined whole rocks and mineral scale investigation. Elsevier, Vol 180- 181, (2013), 43-57.
[6] J. Pearce and J. Cann , Ophiolite origin investigated by discriminate analysis using Ti, Zr and Y. Earth planet sci. lett. 12 (1973), 339-349.
[7] D. Wood, J. Joron and M. Treuil, A re-appraisal of the use of trace elements to classify and discriminate between magma series erupted in different tectonic settings. Eatth Planet. Sci. Lett., 45, (1979), 326-336.
[8] A. Hall, Igneous Petrology. English Language Book Society /Longman, 1987.
[9] Z. Li, Z. Qiu, S. Qin, X. Pan, D. Liang, Y. Teng and Y. Li, A study on the forming condition of basalts in the South China. Chinese Journal of Geochemistry, Vol 13, Issue 2, (1993),107- 117.
[10] N. Villeneuve, D. Neuville, P. Boivin, P. Baccheery and P. Richet, Magma crystallization and viscosity: the study of molten basalts from the Piton de la Fournaise. Chemical Geology, Vol 256, Issue 3-4, (2008), 242-251.
[11] J. Bender, F. Hodges and A.Bence, Petrogenesis of Basalts from the project. Famous area: experimental study from 0 to 15 Kbs. Elsevier. Earth and Planetary Letters. Vol 41, Issue 3, (1978), 277- 302.
[12] H. Yoder and C. Tilley , Origin of basalt Magmas: An experimental study of natural and synthetic rock systems. Journal of Petrology. Vol 3, Issue , (2016), 342-532.