Geochemistry and Industrial Assessment of Limestone Beds in Guyuk Area, Northern Benue trough, Northeastern Nigeria

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Abstract

Limestone deposits occur within sedimentary formations in Guyuk, Nigeria. The growing demand of this crucial resource in Adamawa state and indeed Nigeria calls for its evaluation. Geologic investigation reveals three mappable lithofacies of crystalline limestone, shelly limestone and bioclastic limestone. These are intercalated with shales, mudstones and in some places bioclastic limestone. Chemical analysis of the limestone by X-ray fluorescence analysis reveals a mean composition of CaO (45.43%), MgO (0.46%), Feo3 (2.70%), AL_2O_3 (2.00%), SiO_2 (6.20%). The Silica ratio (SiR) and alumina –iron ratio (AIR) are 1.23 and 0.81 respectively. These parameters suggest a moderate purity limestone that is suitable for the manufacture of Portland cement, lime for agricultural purposes, filler in construction industries, and raw material in the chemical industries.

Keywords: Lithofacies, Bioclast, Limestone, crystalline, Fossiliferous, Dolomitization

INTRODUCTION

Limestone is an invaluable raw material in the chemical industries, cement manufacturing, iron and steel, and glass-making industries as well as agricultural purposes. The growing demand for this crucial resource in Adamawa state and indeed Nigeria calls for the evaluation of the Guyuk limestones to support the infrastructural developmental needs of the country and other industries that require its utilization.

The entire Benue Trough witnessed a transgressional episode during the Late Cenomanian to early Turonian, which led to the deposition of the limestones in Guyuk area of the Yola sub-basin in the Northern Benue Trough. The stratigraphy consists of shale and limestone intercalation in which lenses of continuous and discontinuous layers of gypsum occur within the shale beds, whereas the limestone beds occur as both crystalline and fossiliferous varieties. The fossiliferous limestone outcrops in the northern slope of the Lunguda plateau and continue its exposure toward the east, covering localities of Falwe, Lamza, Dukul, and Sekuliye formations (Mamman *et al*., 2006, Opeloye, 2002 - fig. 2).

The origin of the Benue Trough has long been a cause for debate among researchers. While some linked it to the separation of the African and American plate with the opening of the Atlantic (Hoque and Nwajide 1984), others attribute it to the reactivation of a pre-existing Pan-African transcurrent fault that cut across the continent (Benkhelil, 1987). The Benue Trough is a sedimentary basin that extends from the Gulf of Guinea to the south of Chad Basin in the northeastern Nigeria. It is about 800 km in length and 80-150km in width (Hoque and Nwajide, 1984). The basin contains thick folded sedimentary deposits ranging in age from Albian to Recent (Petters, 1991 - fig. 1).

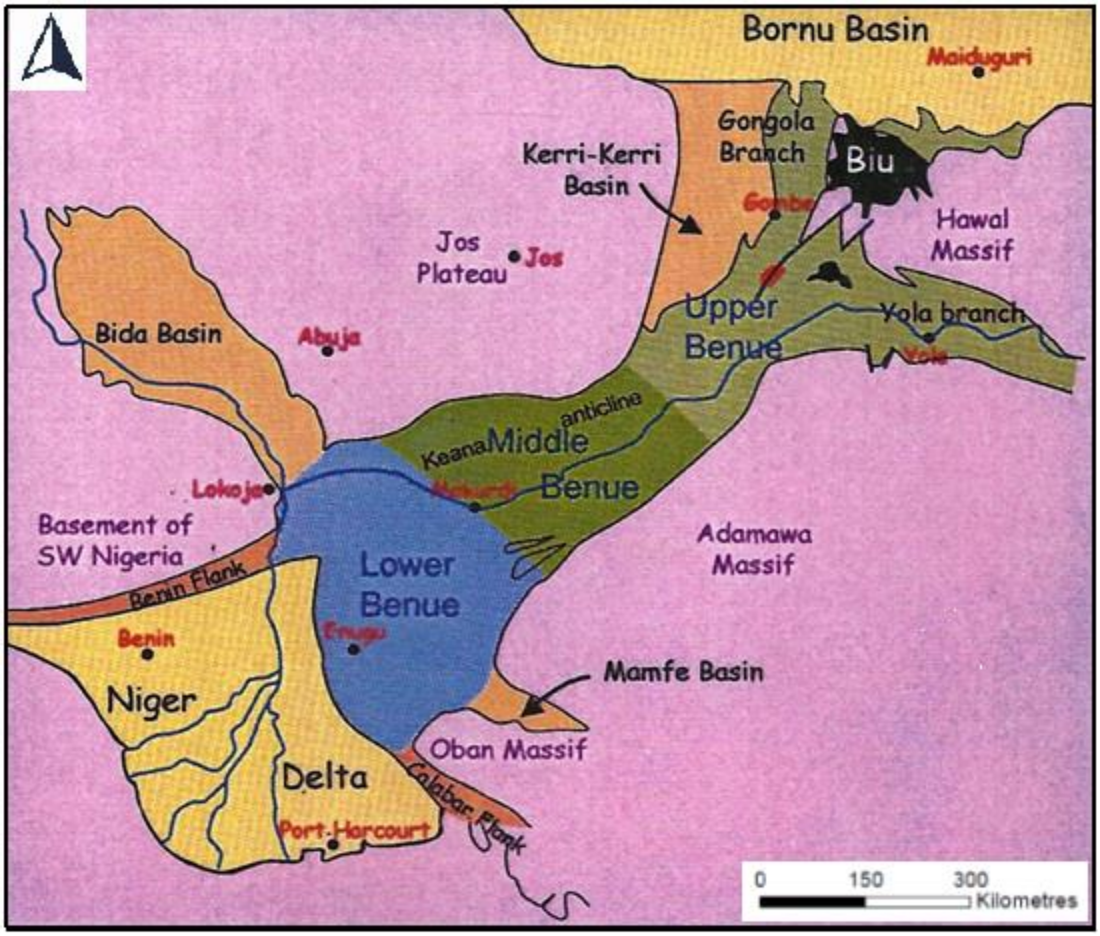

Figure 1: Geological setting of the Benue Trough (Modified after Benkhelil, 1982)

Stratigraphy of the Northern Benue Trough.

The stratigraphic column in the Yola sub-basin of the Northern Benue Trough is shown in (Fig. 3). The Northern Benue Trough is made up of two basins, namely the Gongola Basin and the Yola Basin. In both basins of the Benue Trough, the continental Albian Bima Sandstone lies uncomformably on the Precambrian Basement Complex. It ranges in age from Aptian- early Albian (Allix *et al*., 1981). This formation was deposited under continental conditions (fluvial, deltaic, lacustrine) and is made up of coarse to medium grained sandstone, intercalated with carbonaceous clays, shale and mudstone. The Bima Sandstone was subdivided by Carter *et al.* (1963) into a lower, middle and upper Bima. This division was supported by the works of Allix (1983); Guiraud (1993). The lower Bima Sandstone is a highly variable unit with an overall thickness of 1500 m Guiraud (1993). The Middle Bima is reported to be shally in most parts and was assumed to be deposited under a more aqueous anoxic condition (lacustrine, brief marine).

Its thickness ranges from 100-500 m. The upper Bima Sandstone is fairly homogenous and relatively matured fine to coarse grained sandstone characterized by tabular cross bedding with

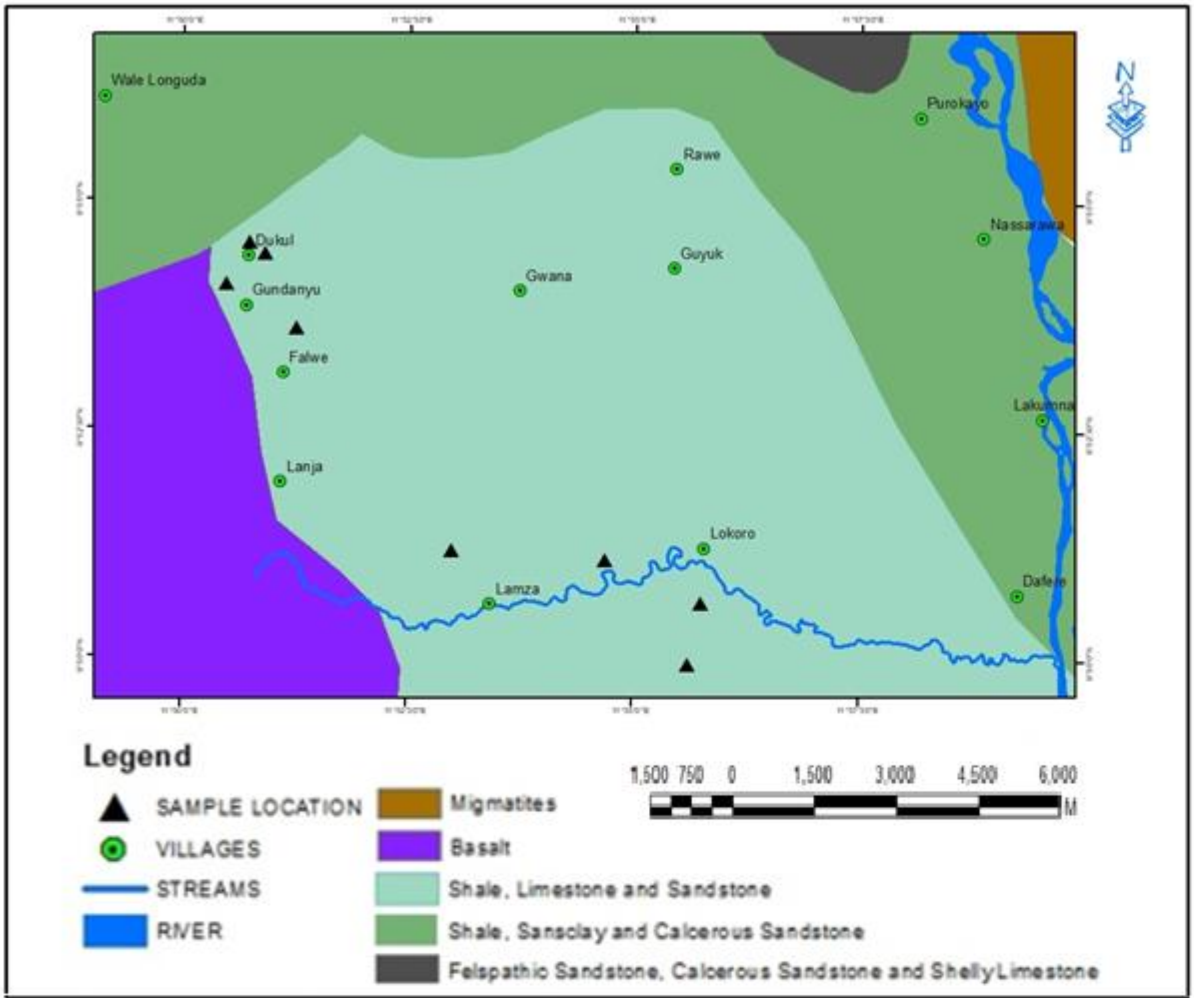

Figure 2: Geological map of the study area

sets ranging from few centimeters to few meters. Convolute beddings and overtuned cross beddings are common and the thickness ranges from 500-1500 m.

The Yolde Formation lies comformably on the Bima Sandstone. This formation of Cenomanian age represents the beginning of marine incursion into this part of the Benue Trough. The Yolde Formation was deposited under a transitional/coastal marine environment and is made up of sandstones, limestones, shales, clays and claystones. It has a maximum thickness that range from 140 to little over 200 m (Thompson, 1958; Lawan, 1982 and Zaborski *et al.*, 1997).

The Dukul Formation overlies the transitional Yolde Formation conformably. This Late Cenomanian-Early Turonian Dukul Formation represents the basal part of the full marine sedimentary sequence in the Yola Basin of the Northern Benue Trough. It comprises of limestones, marlstones, mudstones, and shales with abundant ammonites and pelecypod molluscs. The Dukul Formation is overlain by the Jessu Formation. This formation is dominated by ferruginous and rippled fine to medium grained sandstone and mudstone typical of enclosed marginal marine environment.

The Sekuliye Formation comformably overlies the Jessu Formation. It is made up of interbeds of limestone and shale lithologies, signifying an environment of increased marine influence (Whiteman, 1982 and Genik, 1992). Although the beds of the formation do not contain ammonites like the similar fully marine Dukul Formation, occurrence of rich assemblages of foraminifera and ostracods reveal fully marine paleosea condition during deposition (Opeloye, 2002).

The Numanha Shales that overlie the Sekuliye Formation was first recognized and described as an "argillaceous bed" by Barber *et al*. (1954) and Reyment (1956). Some studies regard this formation as a lateral equivalent of the Lamja Sandstone (Wright, 1985). It is composed of shales with occassional bands of nodular mudstone and limestone.

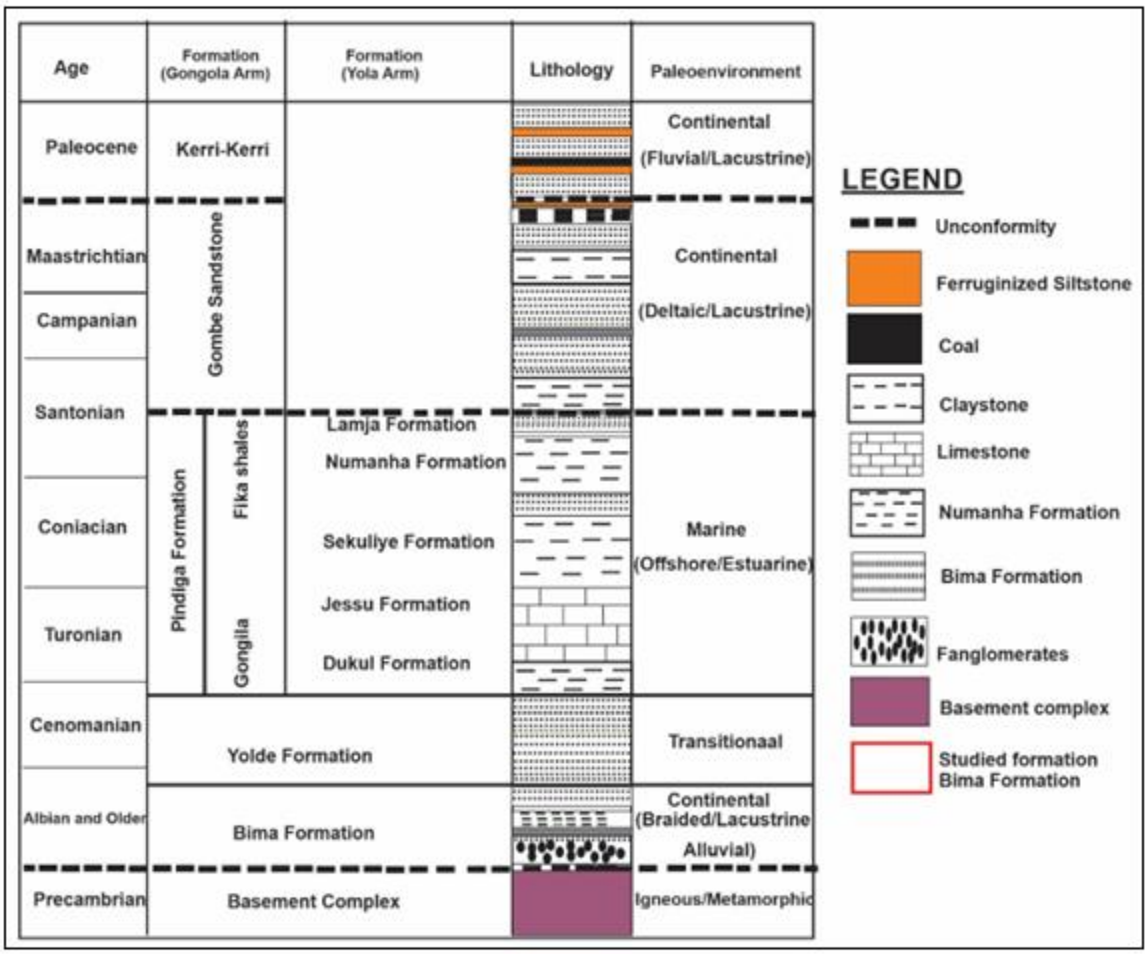

Figure 3: Stratigraphic chart of the Northern Benue Trough (Finthan and Mamman, 2017)

The Lamja Sandstone was first described under the name "Carbonaceous Beds" (Barber *et al.*, 1954). This formation rests on the Numanha Shale and terminates the Cretaceous sedimentary succession in the Yola Basin of the Northern Benue Trough. It consistss of fine to medium grained sandstone, siltstones, carbonaceous beds, shales and limestones. The Tertiary volcanic activities represented by the Longuda Basalts overlie the Lamja Sandstone uncomformably.

MATERIAL AND METHODS

Samples were collected from some identified areas: Dukul, Gundenyi, Lokoro and Lamza. The samples were crushed and pulverized into fine powder of less than 125microns.20g of the powdered limestone samples were mixed with0.4g of stearic acid powder which acted as a buffer so as not to allow the samples to disperse away. The aluminum cup of the X-ray machine was half filled with stearic acid powder followed by the addition of the finely ground sample powder. The cup was put into hydraulic pump compression machine and compressed at 200KN for 10seconds which form pellet. The pellet was put into the X-ray fluorescence sample holder and then into the loading position of the XRF and measure unknown sample was selected and entered into the computer and the program desired was entered. The results were interpreted and displayed after 70-80 seconds on a computer and printed in percentage of elements in the samples. Moisture and organic matter content were determined as Loss on ignition by heating 2g of each sample in a furnace at 9500c for 2hrs.The silica content was determined using sodium carbonate fusion method.

RESULT AND DISCUSSION

The result of the chemical analysis is on table 1. The calcium carbonate values range between 71.55 and 89.20. MgO is relatively below 1.00% with average of 0.64% which is indicative of the absence of dolomitization (Petttijohn, 1975). Na_2O and K_2O appear in traces with mean average values of 0.03 and 0.12 % respectively. Loss on ignition (LOI) which reflects the moisture and organic matter content obtained from the samples were relatively high with mean value of 36.36%. The CaO constitutes the dominant constituent of the limestone samples in the study area with values ranging between 40.09 to 49.98% with mean value of 45.43%. The SiO_2 has a mean value of 6.20 %. This value of concentration according to Mason (1966); Taylor (1996) is relatively high in purity.

The low values of Na_2O and K_2O (0.12% and 0.03%) in the samples may be attributed to weathering of the associated shale horizons which led to the incorporation of the oxides in trace amounts in the limestone.

Industrial Use

Limestone is an essential raw material in the chemical industries, cement manufacturing, iron and steel as well as glass making industries. Geochemical assessment is useful to appropriate specific industrial applications for the deposit.

In cement manufacturing industries, limestone and shale are mixed in the proportion of 4:1 and fired in a furnace to produce clinker which is responsible for cement strengthening. Three chemical ratios are considered in determining the $CaCO_3$ percentage than can be combined in a mix to form a good clinker. The ratios are the limestone saturation factor (LSF), silica ratio (SiR) and alumina ion ratio (AIR) with specified ranges of >90, 1.50 to 4.00 and 1.40 to 3.50 respectively (Scott, 1984). The chemical properties of the Guyuk limestone reveals values of SiR and AIR to be below the standard for quality Portland cement. However the LSF is within the range for production of quality cement. The limestone of the study area could be utilized in chemical industries to produce fungicides and insecticides and also in the paper and plastic industries as extenders and fillers.

Sample No.	Du1	Du2	Du3	Gu4	Lo5	Lo6	La7	La8	Mean
$Si\ O_2$	10.75	5.34	3.10	5.49	9.16	2.71	6.31	6.81	6.20
$Al_2\ O_3$	3.55	1.77	1.03	2.36	2.47	1.01	1.80	2.18	2.00
$Fe_2\ O_3$	2.51	2.48	1.87	2.25	5.24	2.54	3.79	2.70	2.92
CaO	44.43	47.08	49.98	47.18	40.09	47.33	43.10	44.25	45.43
Mg O	0.40	0.91	0.39	0.48	0.99	0.63	0.84	0.50	0.64
$K_2\ O$	0.58	0.01	ND	0.16	ND	ND	ND	0.01	0.03
$Na_2\ O$	0.12	0.10	0.08	0,09	0.12	0.15	0.15	0.14	0.12
$Ti\ O_2$	0.18	0.10	0.06	0.12	0.14	0.06	0.09	0.08	0.10
$CaCO_3$	78.98	84.03	89.20	84.20	71.55	84.47	76.93	78.98	81.05
LOI	35.31	38.00	39.66	37.56	32.55	37.84	34.75	35.28	36.36
LSF	123.68	252.26	449.70	240.30	125.40	452.96	193.42	188.49	237.60
Si R	1.77	1.257	1.06	1.19	1.18	0.76	1.30	1.36	1.23
A1.R	1.44	0.713	0.55	1.04	0.47	0.39	0.47	0.78	0.81

The agricultural application of limestone is liming acidic soil for improved crop production. A low threshold value of 32.20% CaO is required for the process (Rayer, 1979). Lime contents in each of the analyzed samples in the study area has CaO values exceeding this specification. However, if crushed to less than 4.00mm particles size and calcined to form lime, it would be useful in soil stabilization. For aesthetic purposes, the shell fragments within the limestone in the study area can be polished and made into attractive stones.

CONCLUSION

The geochemical analysis of the limestone at Guyuk revealed that they are suitable to produce fungicides, insecticides, paper and plastic products. It can also be useful for agricultural purposes and in the construction industries.

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