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Study of the Geochemical Analysis of Mbatiav Limestone Deposit for the Production of Cement

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Abstract
Study of the geochemical analysis of Mbatiav limestone deposit for the production of cement was carried out to ascertain the suitability of the limestone deposit for the production of cement. Core samples from different holes were analysed for oxides and alkalis using X-Ray Fluorescent photometer (XRF). Chlorides were determined using Silver Nitrate ($AgNO_3$) potentiometer titrations while sulphites were determined using gravimetric methods and using Barium chloride ($Bacl_2$) as the precipitating agent. The results of the geochemical analysis showed that the deposit contained high grade limestone with CaO percentage ranging from 42.96% – 49.06%, with an average of 46.66% for subsurface samples, and 37.84% – 51.14%, with an average of 43.72% for outcrops. In general, the results showed that the limestone deposit satisfy the CaO and other contents for cement production, provided SiO_2, Al_2O_3, and Fe_2O_3 contents satisfy the ultimate moduli values of raw mixes.

Keywords: Mbatiav, Limestone, Geochemical analysis, Core samples, Cement, Benue trough.

Introduction

Limestone is an essential mineral commodity of national importance and it is a rock composed mainly of calcium carbonate ($CaCO_3$), it is sedimentary in origin and has shades of colours ranging from light gray to very dark gray [1]. Limestone usually contains variable amounts of silica, clay, silt and sand as nodules, or layers within the rock [2]. Limestone is used to produce cement, as an aggregate in concrete and asphalt and in other products used in the building and construction sector generally [3]. This paper highlights the study of the geochemical analysis of Mbatiav limestone deposit and its suitability for use in cement manufacturing. The area of study, Mbatiav, lies within the longitude E8^0 4' - E8^0 55' and latitude N7^0 10' - N7^0 20' in Benue state, Nigeria [4]. Benue state lies entirely within the river Benue valley that is geologically called the Benue trough [5]. The geological history of the Benue trough started during the opening of the South Atlantic about a triple junction, which included the Niger River valley (the Niger/Benue trough). The separation of the North Atlantic - African plate from the South Atlantic – African plate resulted in the formation of the Benue depression during an erogenic episode in the Santomian times [6]. During the tertiary, and possibly the interglacial periods of the quaternary glaciations, the Benue and the Niger trough were transgressed by the waters of the Atlantic Ocean. As a result, marine sediments form the dominant surface geology of Benue state [7]. Thus, from the Albian to Santomian times there was continuous deposition in the Benue depression which led to the formation of limestone and other sedimentary based mineral deposits like shale, clay, sandstone, marl, siltstone and intercalated deposits [8, 9]. An area of approximately 3.4km^2 was investigated. The core holes locations were set out in a 2,000m by 1,500m grid with 500m spacing between the borehole locations. A total of 16 core holes were drilled. The total length of core samples drilled was 402m. Once a limestone deposit has been verified, it is necessary to undertake a thorough assessment to determine the composition of the reserve. The assessment, which comprises a detailed geochemical analysis, is crucial to ensure the deposit meets the requirements for cement production. Among others, [3, 7] have contributed to this study, however, it is very important to further carry out a detailed geochemical analysis of the Mbatiav limestone deposit in order to determine the occurrence of limestone in the Mbatiav area, determine the qualitative composition of the limestone and ascertain the viability of the limestone in the explored area for commercial cement production.

Materials and Methods

A total of four drilling rigs were used for the exploration. Three of the rigs were truck mounted while one of the rigs was a stationary coring rig. All the rigs use rotary method of drilling and were designed for coring purposes. The drilling installation consists of drilling equipment, pumping plant and drive engine. The drilling equipment associated with each rig consisted of a derrick, headgear (for lowering into the borehole and hoisting the boring rods and barrels), bore rods (drill pipes), bits, core barrel, adapter (reducer), and a core catcher [10]. A swivel suspended from a pulley block is screwed on the top end of drill pipes. A hose connected to the pump forces the drill fluid into the borehole. The hose was connected to the headgear swivel which was attached to the drilling rods and the fluid was passed into the core holes through the hollow shaft in the drill rods. The flushing of the core holes was done by the pump plant which takes drilling fluid from the mud pit and forces it into the hole through the delivery hose and swivel. The fluid returns to the surface through the annular hole mouth, passes through a trough, settling pit (tank) and then to the mud pit. Other drilling accessories are mixing hopper, tongs, wrenches and gripping forks [11]. Drilling fluids consist of water, bentonite clay, and other additives used to regulate viscosity and seal permeable formations [12]. The drilling and coring was done by the rotary movement of the drill head, causing penetration into the rock. The coring and capture of the core was done by the bit (diamond bit) and core barrel [12]. The core barrel was pulled out of the hole to recover the core upon filling. The core was then washed and measured and cut to an appropriate size to fit into available core boxes and then logged by a geologist [13]. A 76mm core barrel which cuts a core of 60mm diameter was used for drilling [11]. Sample preparation involved splitting the core samples without destroying the intensity of the samples [11]. Core splitting was done using diamond coated cutting blades and paying close attention to geological changes in the rock formation [3]. Where heterogeneity occurs, samples were taken at intervals of 0.50 to 1.00m [3]. It is on the basis of this sampling method that the number of samples to be analysed, per hole was determined.

Results and Discussion

Table 1: Chemical composition of Mbatiav limestone, subsurface (oxides %)

Classification	SiO_2		Al_2O_3		Fe_2O_3	CaO
High grade limestone (HGL)	5.76 – 14.13		1.59 – 3.86		0.66 – 1.74	42.96 – 49.06
Calcareous Marl	17.45 – 19.70		5.88 – 6.20		2.44 – 5.34	35.09 – 38.90
Shale (Argillaceous material)	44.50 – 50.60		11.35 – 13.68		5.42 – 13.68	1.21 – 13.84
Clay (Argillaceous material)	49.38 – 69.04		6.55 – 18.85		6.92 – 16.24	0.22 – 6.16
Laterite (Argillaceous material)	27.45 – 56.39		6.53 – 18.54		15.98 – 41.65	0.09 – 15.70

Table 2: Chemical analysis of outcrops

Sample	SiO_2		Al_2O_3	Fe_2O_3		CaO
Outcrop 1	20.64		5.26	2.06		39.57
Outcrop 2	4.83		1.20	0.63		51.14
Outcrop 3	5.86		1.53	0.63		50.02
Outcrop SS1	13.01		2.95	1.16		45.92
Outcrop SS2	12.68		2.95	1.21		45.75
Outcrop SS3	18.28		4.50	3.44		38.00
SS 4	15.82		4.67	1.69		41.52
SS 5	17.41		6.42	3.16		37.84

Table 3: Number of samples analyzed

Core holes	Number of samples analyzed	Core hole Depth (M)
A	11	13.67
D	9	29.80
E	13	31.00
F	12	26.50
H	10	31.00
I	15	30.50
K	10	19.80
L	8	20.00
M	11	18.42
N	13	18.00
R	9	10.87
S	18	27.16
T	24	30.20
V	10	34.83
Y	12	30.66

Z	14	30.46
Total	199	402.37

Table 4: Core holes classification

Core holes	Classification
A	Calcareous marl (low grade limestone)
D	Shale
E	Calcareous marl (low grade limestone)
F	Limestone
H	Shale
I	Calcareous marl (low grade limestone)
K	Shale
L	Calcareous marl (low grade limestone)
M	Limestone
N	Intercalated shale and marl
R	Limestone
S	Limestone
T	Limestone
V	Limestone
Y	Intercalated shale and marl
Z	Limestone

The grid pattern of the sixteen core holes was controlled by climatic and topographic conditions. All together sixteen holes were drilled. Drilling showed that eleven core holes consisted of limestone (either partially or at complete full depth) and five holes without limestone (argillaceous material). These five holes mark the limestone boundary. Tests carried out on the outcrops indicated that samples from outcrops 2, 3 and SS 1 and SS 2 consisted of limestone, while outcrops 1, SS 3, SS 4, and SS 5 consisted of limestone partially. The total length of core samples drilled was 402m. The results of geochemical analysis showed that the deposit contained high grade limestone with Cao percentage ranging between 42.96% and 51.14% with subsurface average of 46.66% and surface average of 43.73%. Other oxides like Al2O3, SiO2, and Fe2O3 were determined and their percentage compositions reported.

Conclusions

Study of the geochemical analysis of Mbatiav limestone deposit for cement production was carried out to examine the chemical composition of the deposit and determine its viability for the production of cement. The result of the geochemical analysis showed that the Mbatiav limestone deposit contain high grade limestone and some area of the studied area also contain low grade limestone which can be blended with the high grade limestone and argillaceous material to produce a good quality mix. The utilization of the Mbatiav limestone deposit for cement production will greatly help in reducing the importation of cement into the country and position the country to be an exporter of cement which will aid in job creation and infrastructural development.

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