Verification of rock density over some parts of Gwagwalada area, Nigeria.

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Abstract: The verification of density of rocks in some part of Gwagwalada Area Council of FCT-Abuja, was carried out to asses the effects of geographical variations on geophysical parameters which include density of rocks. This research paper describes a methodological approach using a direct measurement on rock samples in the laboratory. The volume of the rocks and the resulting density is then calculated from the computational approach. The results of the experiments and field studies that examined the rock density are then compared with the available lithological data (reviewed result). The data presented in this research work were gathered from the experiments conducted in the university of Abuja Physics laboratory and from the field studies observed from about eight locations within the research areas, which include Zuba, Yimi, Giri, Gwako, Paiko, Dobi, Anagada and Gwagwalada. In this investigation we have examined a suite of samples (20 specimens) with density ranging from 2.20g/cm^3 to 3.06g/cm^3.

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1.0 INTRODUCTION

The solid part of the earth is made up of rocks. Rocks in turn are made up of minerals and minerals are composed of chemical elements (Poldervaart, 1955). Minerals are to rocks as letters are to words. Stone refers to rock used in blocks to construct buildings or crushed to form roadbed. Most stones in buildings are limestone or granite. Marble in particular is a precious rock, often used to decorate floors, mosques, churches and tomb stones (Abegunde and Adegoke, 1998).

This natural body (rock) provides humanity with valuable materials and mineral resources in varying degree of usage depending on both the physical and chemical characteristics of such rocks. The economic value of limestone and their role as storage reservoirs for both petroleum and groundwater have provided incentives for their study (Geze, 1965).

Rocks provide employment opportunities for both skilled and unskilled labour. For example, limestone is used in making cement and also in demand as a soil conditioner as well as the principal ingredient of many chemical products.

The principal factors controlling the strength of solid rocks are density and porosity (Augustinus, 1991). Density is important in various undertaking in the mining industries. Specific gravity is used in the separations of minerals. Architects and engineers used the knowledge of density in the design of bridge, flyovers and other structure (Abott, 1998).

There is an apparent increase in the collapse of buildings, bridges, flyover, roads and as well as other structures in both developed and developing countries including Nigeria. This may be due to the fact that there are several rock types and minerals present in the world and many of them look alike and this makes their identification difficult. The non-diagnostic property of a particular rock type in construction of building or bridge could lead to disaster in form of collapse of the structure.

Therefore, this research work is aimed at not only providing the identification properties of the rock and mineral types but also to reveal their various significance to human race.

1.1 LOCATION AND ACCESSIBILITY OF THE RESEARCH AREA

The area is located about 55kilomitres away from the federal capital city. It lies between latitudes 8^{0}55' north and 9^{0}00' North and longitudes 7^{0}00' East and 7^{0}05' East. (Gwagwalada Master Plan). The area covers a total of 65 square kilometers located at the centre of very fertile agricultural area with abundant clay deposits. It is located along Kaduna - Lokoja road.

The sunshine of the area ranges between 8 to 10 hours during the period of January to April/May. With regard to temperature, the area records its highest temperature during the dry season months at 38^{o}c. The start of rain is from March and end around October (Dawam, 2000).

The survey areas are part of the Nigerian basement complex,which occupied mainly hills and dissected terrain (Dawam, 2000). The rocks consists of schists, gneiss and some older granites. The map in fig.1 shows the various locations where the samples were collected.

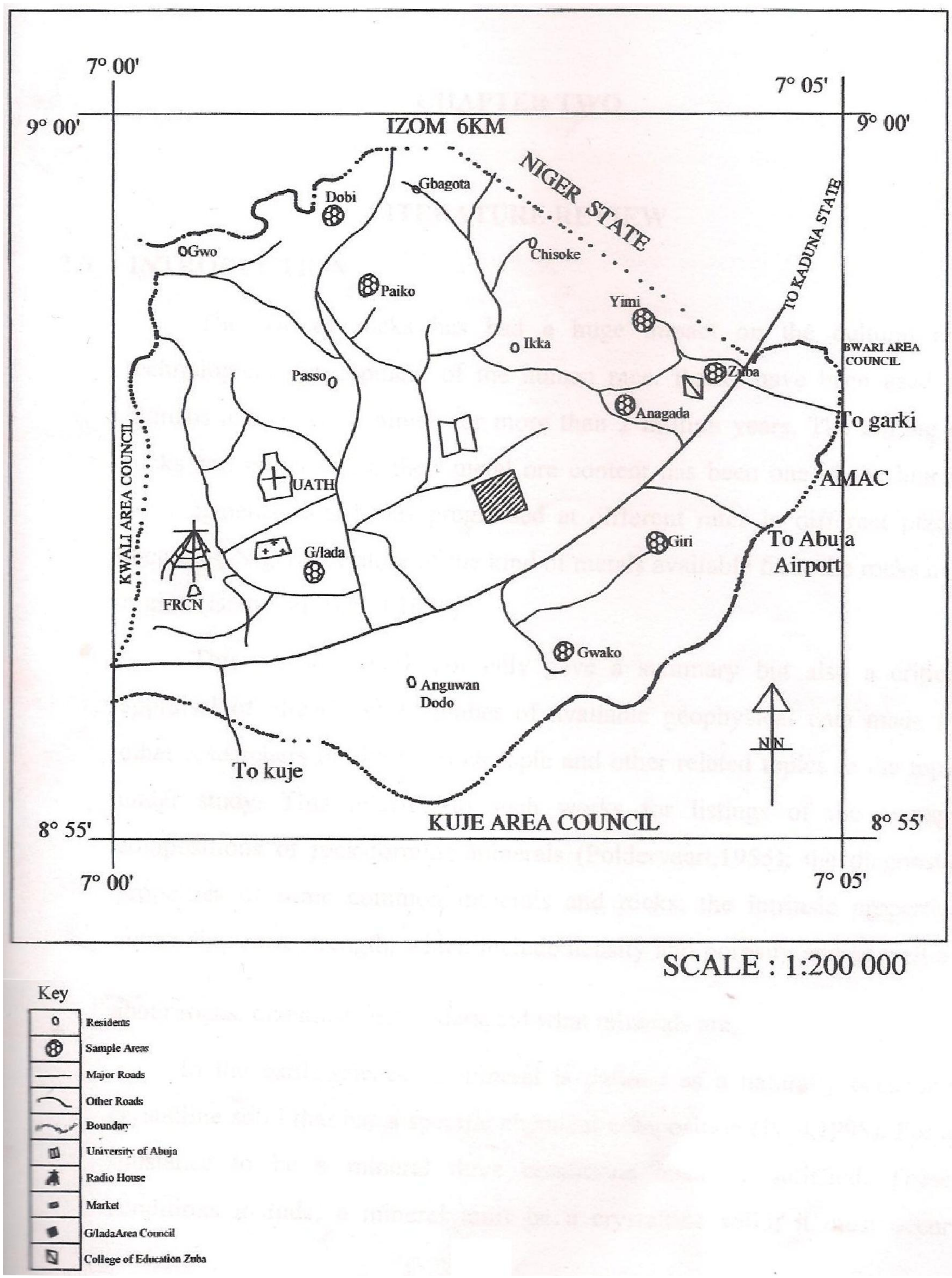

Fig 1: The approximate field location showing the survey area

METHODOLOGY

There are several methods (direct or indirect) of determining the bulk density of rocks. For the interest of this research work, the laboratory method was adopted for the investigation of density of some surface sample of rocks in some selected locations within the research area. This method can be observed on a small sample of rock in a laboratory (Athy, 1930). The method is well guided by Archimedes's Principle.

Sampling was done so as to obtain specimen that represent the situation under study. Sampling is therefore a small portion of material representing a large population. Two or more samples were collected each from eight (8) villages within Gwagwalada geographical area; two samples from Gwagwalada; three from Zuba; three from Giri; two from Paiko; three from Anagada; two from Dobi; three from Yimi and two from Gwako, making a total of twenty (20) different samples.

Samples for this study, after the collection, were broke into a measurable size and shape. The samples were then dried properly for six to eight hours so as to remove the moisture contents, before the actual measurement was taken.

DENSITY VERIFICATION

The density of a sample is defined as its mass per unit volume. The density is measured in units of kg/m^3 or g/cm^3.

In this, work two different types of density were determined;

(i) The dry density P, the dry mass M_d of the sample divided by the total volume, V of the sample. The sample must be dried long enough to remove any moisture from the voids.

(ii) The relative density also known as specific gravity (SG) of rock, the ratio of the weight of rock in air (W_d) and loss of weight ($W_d - W_w$) in water.

(iii)

Mathematically;

$$\mathbf{P} = \frac{\mathbf{M_d}}{\mathbf{V}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(1)}$$

$$\mathbf{S.G} = \frac{\mathbf{W_d}}{\mathbf{W_d - W_w}} \quad \ldots\ldots\ldots\ldots\ldots..\mathbf{(2)}$$

For this wor, water was use as the fluid (P_f = $1.0g/cm^3$).

Spring balance, thread, graduated cylinder (5000ml), bucket and water, stand and rocks were used as the density measuring instruments.

The dry weight (W_d) of each sample was taken using the spring balance. The graduated cylinder was then filled with water to a level that covered the sample completely, the volume of the water was taken as V_1. By means of a thread, each sample was fully submerged in the cylinder containing the water. And the volume was then recorded as V_2.

The total volume, V of each sample was obtained by subtracting V_1 from V_2.

i.e. $V = V_2 - V_1$

The density was then computed using the relationship given in equation (1).

Hence specific gravity (SG) obtained using the relation in equation (2).

RESULTS AND ANALYSIS

All data presented in this work have been subjected to careful computational and statistical analysis and have been shown to be highly significant.

Lithological data and measured values of density of rocks are compared using tables (i) and (iii). Virtually all the measured values of density are within the lithology range given in table (i) and (ii) except in serial number 4 and 13 of table(iii) where deviations are 0.01and $0.16g/cm^3$ respectively. This suggests that density is controlled by fundamental processes that are common to all rocks. And the close correspondence of the measured and lithology densities therefore indicates that the computational approach adequately handles these textural and mineralogical variations.

However, great variations are observed in density for a particular identical rock types. Gneiss for example varies in density from $2.60g/cm^3$ to $2.83g/cm^3$ respectively for the four samples of gneiss. These may be due to three major important reasons:

i. Measurement errors due to the inherent uncertainties in input and calibration data on the instrument used.
ii. Geometrical variables. Micro scale variation in texture (the grain size and the degree of sorting).
iii. Physicochemical variables are also important. These include temperature, stress, chemistry of the pore water, mineralogy and weathering process.

Table (i): The approximate Density ranges for common rock types and ores (Phili etal,2002)

ROCK TYPES	RANGE OF DENSITY (g/cm^3)
Alluvium (wet)	1.96 – 2.00
Clay	1.63 – 2.60
Shale	2.06 – 2.66
Sandstone	2.05 – 2.55
Limestone	2.60 – 2.80
Chalk	1.94 – 2.23
Dolomite	2.28 – 2.90
Glass	2.40 – 2.80
Halite	2.10 – 2.40
Granite	2.52 – 2.75
Granodiorite	2.67 – 2.79
Anorthosite	2.61 – 2.75
Basalt	2.70 – 3.20
Gabbro	2.85 – 3.12
Gneiss	2.61 – 2.99
Quartzite	2.60 – 2.70
Amphibolites	2.79 – 3.14
Chromite	4.30 – 4.60
Pyrrhotite	4.50 – 4.80
Magnetite	4.90 – 5.20
Pyrite	4.90 – 5.20
Cassiterite	6.80 – 7.10
Galena	7.40 – 7.60

Table (ii): Typical Compressional wave velocity values and ranges for some common rocks andand ranges for some common rocks and minerals (Phili etal, 2002).

ROCK TYPES	Vp (Kms^{-1})
Sandstones	2.0 – 6.0
Carboniferous	4.0 – 4.5
Cambrian quartzite	5.5 – 6.0
Limestone's	2.0 – 6.0
Cretaceous Chalk	2.0 – 2.5
Carboniferous Limestone	5.0 – 5.5
Dolomites	2.5 – 6.5
Salt	4.5 – 5.0
Anhydrite	4.5 – 6.5
Gypsum	2.0 – 3.5
Granite	5.5 – 6.0
Gabbro	6.5 – 7.0

Ultramafic Rocks	7.5 – 8.5
Serpentinite	5.5 – 6.5

Table (iii): Density Data Presentation

S/No	Location	Classes of Rock	Rock Type	W_d (N)	W_w(N)	M_d (gm)	V_1(cm^3)	V_2 (cm^3)	V (cm^3)	Density (gm/cm^3)	S.G
1	G/lada	Igneous	Quartz	6.4	3.9	640	3000	3250	250	2.56	2.56
2	G/lada	Metamorphic	Quartzite pebble	5.4	3.4	540	3000	3200	200	2.7	2.7
3	Zuba	Igneous	Basalt	8.6	5.6	860	3000	3300	300	2.87	2.87
4	Zuba	Metamorphic	Gneiss	7.8	4.8	780	3000	3300	300	2.6	2.6
5	Zuba	Metamorphic	Schist	6.1	3.6	610	3000	3250	250	2.44	2.44
6	Giri	Igneous	Granite	8.2	5.3	820	3000	3300	300	2.73	2.83
7	Giri	Metamorphic	Marble	8.7	5.6	870	3000	3325	325	2.68	2.81
8	Giri	Metamorphic	Quartzite	5.2	3.2	520	3000	3200	200	2.6	2.6
9	Paiko	Sedimentary	Sandstone	5.5	3	550	3000	3250	250	2.2	2.2
10	Paiko	Metamorphic	Schist	9	5.7	900	3000	3325	325	2.77	2.73
11	Anagada	Igneous	Gabbro	5.2	3.4	520	3000	3170	170	3.06	2.89
12	Anagada	Sedimentary	Chert	6.5	3.7	650	3000	3280	280	2.32	2.32
13	Anagada	Igneous	Weathered Granite	6.6	3.8	660	3000	3280	280	2.36	2.36
14	Dobi	Igneous	Pegmatite	6.3	3.6	630	3000	3250	250	2.52	2.33
15	Dobi	Metamorphic	Gneiss	7.6	4.8	760	3000	3290	290	2.62	2.71
16	Yimi	Metamorphic	Dolostone	5.6	3.2	560	3000	3240	240	2.33	2.33
17	Yimi	Metamorphic	Gneiss	8	5	800	3000	3300	300	2.67	2.67
18	Yimi	Metamorphic	Marble	8.1	4.3	810	3000	3300	300	2.7	2.7
19	Gwako	Metamorphic	Gneiss	9.2	6	920	3000	3325	325	2.83	2.88
20	Gwako	Metamorphic	Quartzite	5.3	3.3	530	3000	3200	200	2.65	2.65

CONCLUSION

The highest density value (2.20g/cm^3) is represented by sandstone. The volume and mass, the sample size has no effect on density of rocks. Gabbro, for example, has the smallest size but represented the highest density (3.06g/cm^3). Gabbro can therefore be used in all sorts of construction.

The variation in density for a particular rock type gives an insight on the need of investigating even the same rock types before using them for a particular project, as some rocks have been subjected to greater pressure, temperature and weather conditions than others due to variations in geographical locations. Gneiss, for example has densities ranging from 2.6g/cm^3 to 2.83g/cm^3 respectively.

It is apparent from this study to note that there is considerable overlap between different rock types and consequently, identification of a rock type is not possible solely on the basis of density data only.

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