DENSITY CHARACTERIZATION OF ROCKS WITHIN HAWUL, BORNO STATE, NORTH-EAST NIGERIA.

SUNDAY DAVID NAJOJI[1], MOHAMMED MOHAMMED YALWA[2] AND ALIYU AHMED MALGWI[2]

[1]School of General & Remedial Studies, Department of Basic Science. Federal Polytechnic Damaturu. [2]School of Science & Technology, Department of Science Laboratory Technology, Federal Polytechnic Damaturu.

Abstract

In this research work, the density of rocks within the Hawul area of Borno State was investigated. The high-density rock may be due to the presence of heavy metals and radioactive elements such as uranium which can affect the environment as well as plants and animals' health. A total of twenty samples were collected from the hill (host rock) and from other locations in the vicinity of the host rock. The method employed for density measurement is the direct mass volume where ten samples from each site were investigated of different rock classification. The data obtained were processed using statistical data analysis and the result shows gabbro gabbro (mean ρ~2.32 ± 0.72 g/cm^3), basalt (mean ρ~ 2.41 ± 0.29 g/cm^3), sandstone (mean ρ~ 2.21 ± 0.59 g/cm^3), granite (mean ρ~2.27 ± 0.61 g/cm^3) and shale (mean ρ~2.50 ± 0.36 g/cm^3). These slightly vary as compared to the standard values for the types of rocks considered. Since the density of rocks vary significantly among different rock types because of differences in mineralogy and porosity, the knowledge of the distribution of underground rock density should be improved and encouraged to help in finding the subsurface geologic structure and rock type that would be essential for building and construction.

Keywords: *rock, density, mass, volume, heterogeneity.*

Introduction

Density is an important property of any material which when measured accurately can help in interpreting a lot about the substance. It is an important physical property of rocks that can affect other physical properties and its importance to both geoscience and geoengineering cannot be overemphasized. According to Lin et al. (2015), density and porosity are fundamental and important physical properties of rocks in various geological problems and affect the other physical properties. Therefore, measurements of density and porosity of rock samples are important investigation items in both geoscience and geoengineering areas. Density and density contrasts of rocks controls gravity anomalies and is an important physical property of geologic material which aids in the identification of rocks, estimation of ore abundances, and assessing rock conditions (Omosanya, 2012). Density measurements are extremely important because they provide a first order indication of textural homogeneity, or heterogeneity, of the magma at the fragmentation level (Shea et al., 2012). According to Ugwoke et al. (2018) there is evidence that densities and durability can serve as relative indices in distinguishing different rock petrologic types.

There are various ways of measuring density such as by direct weighing (Archimedes principle) using specific gravity and direct mass-volume method. These methods are used depending on the state of the substance i.e. solid, liquid or gas. For this research, the samples are in a solid state. Density has been defined by many researchers as the ratio of the mass of a substance to the volume it occupies (Crawford, 2013; Najoji, 2017; Hellstrom et al, 2017). The equation is given by;

$$\rho = \frac{M}{V} \qquad (1)$$

where ρ is the density, M is the mass and V is the volume of the substance.

The fact that rocks are naturally formed solid mineral consisting of heavy and denser elements such as alluminium, zinc, copper, uranium, etc are elements that possess a significant plant and animal risks in the Hawul area. The contamination of water by these elements can affect the rate of growth and water supply used by animals especially in shallow wells (Yalwa and Malgwi, 2010). The growth of plants may also be determined by the textural arrangement of the rocks. The high density of a rock may be due to the presence of heavy metals and radioactive elements such as uranium which also play an effective role in plant and animals' health as well as the environment. This research work will enable us to solve some of these problems.

Several works have been carried out on the density measurement of substances among which are the experimental study on measurement methods of bulk density and porosity of rock samples (Lin et al., 2015) where they observed that different measurement methods produced almost the same results for the bulk densities of the substance. Also, Geng et al. (2020) carried out the bulk density homogenization and impact initiation characteristics of porous PTFE/A1/W reactive material where they observed a density homogenization zone and a sensitivity transition zone. Among these studies none has carried out the characterization of rock types within the Hawul area of Borno State as such this work became necessary. This work seeks to characterize the different rock types found within the Hawul area of Borno State.

The study area

Borno state has a total land mass of 69,435 sq.km and lies between latitude 10˚N to 13˚N and longitude 12˚E to 15˚E. The greater part of the state lies on the Chad basin. It is bounded to the west by Yobe state, to the north by Niger and Chad republics and to the East by Cameroon republic while the southern part is bounded by Adamawa and Gombe states. Hawul is one of the twenty-seven (27) local government areas of Borno state located in the southern part of the state. It shares boundaries with Biu, Shani, Kwaya Kusar, and Bayo local government area as well as Gombi local government area of Adamawa state. Hawul lies generally at an altitude of about 600 m above sea level even though some areas might be lower. Temperatures that would be expected, generally high in the town with mean daily maximum temperatures ranging from 29.2˚C in July and August to 37.6˚C in March and April. The mean daily minimum temperature ranges from about 11.7˚C in December and January to about 24.7˚C in April and May (Joshua, 2015). Its *headquarters* are in the town of Azare. It has a population of 120,733 at the 2006 census (Wikipedia). The location map of the Hawul area is given in figure 1.

Materials and Methods

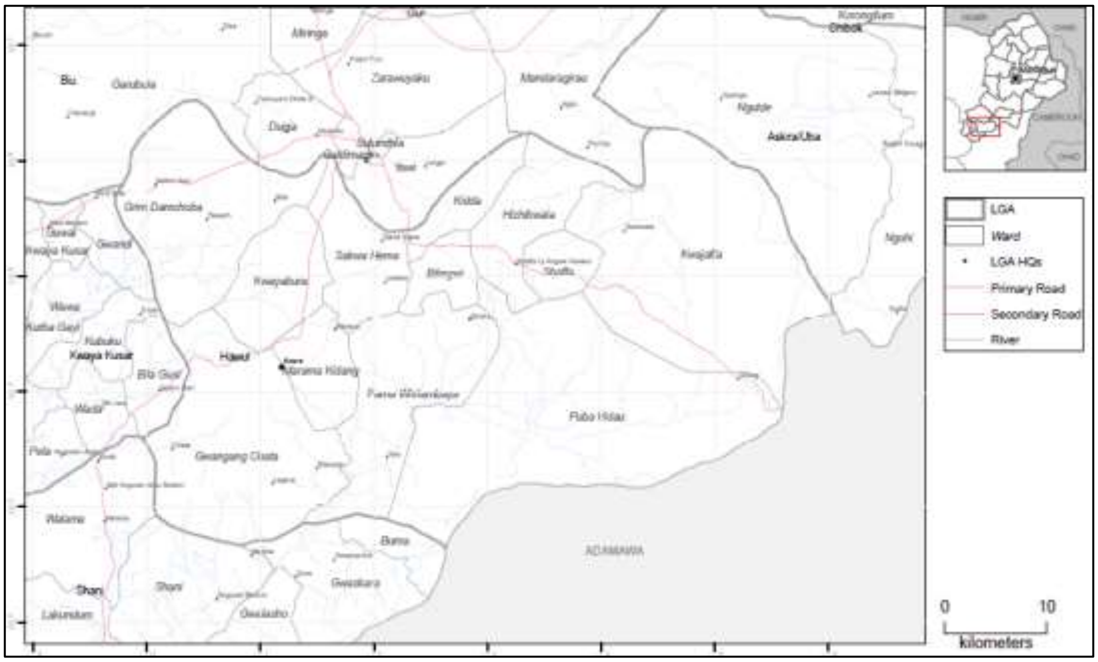

Figure 1. Location Map of Hawul Area of Borno State (Source: Google maps)

Sample Collection

A total of twenty (20) samples were collected ten (10) from the lower hills while the other ten (10) from around the hill using a chisel and hammer. Those from the lower hill were crushed and collected while those from the vicinity were randomly picked. The samples collected were labelled and kept separately in bags and taken to the Laboratory. This random collection was done to ensure that whatever is obtained as the result of our measurement represent the density of the whole of that particular hill.

Mass – Volume Measurements

The mass of each sample was obtained by placing the sample on a digital weighing balance and their corresponding readings displayed were recorded. The volume of the rock samples were obtained by immersing each sample inside a graduated beaker. The initial volume of the water in the beaker was noted and the final volume when each rock sample was immersed. The volume of water displaced by each sample was taken as the volume of each rock sample. By employing equation (1), the density of each rock sample was obtained.

Results and Discussion

The densities of the host rock types of Hawul which include gabbro, basalt and sandstone are given in table 1 while those within the vicinity which consist of granite and shale are given in table 2. The mean densities of the Hawul rocks and their standard deviations are given in table 3. The range in the densities of the rocks and their standard densities are shown in table 3 for the sake of comparism. The variation in the density of the specific rock types is an indication of heterogeneity in the mineralogy and porosity of the same rock types as such even the standard values are usually given in terms of range. Considering the different rock types, it is evident that because of different mineral composition of such rocks the density varies. Generally, even the mean density of the rock types of Hawul area slightly vary from the standard values as expected hence even the standard values are given as a range. Though the rock density values obtained in this work is still within the range of the standard values.

Table 1. Density of host rock, mean and standard deviation

S/N	General Rock Type	Specific	Rock Density (g/cm^3)	Mean (g/cm^3)	Deviation	$(Deviation)^2$	Variance (g/cm^3)	Standard Deviation
1	Igneous	Gabbro	1.8125	2.320	-0.5075	0.257556	0.5157	0.7181
2			2.5833		0.2633	0.693268		
3			2.5642		0.2442	0.596336		
4		Basalt	2.7333	2.4116	0.3217	0.103490	0.0852	0.2919
5			2.0266		-0.3850	0.148225		
6			2.4750		0.0634	0.004020		
7	Sedimentary	Sandstone	1.7625	2.2114	-0.4489	0.201511	0.3490	0.5908

8	2.0500	-0.1614	0.260499
9	2.5000	0.2886	0.832899
10	2.5333	0.3219	0.103620

Table 2. Density of vicinity rocks, mean and standard deviation

S/N	General Rock Type	Specific Rock	Density (g/cm^3)	Mean (g/cm3)	Deviation	$(Deviation)^2$	Variance (g/cm^3)	Standard Deviation
1	Igneous	Granite	3.2645	2.7232	0.5312	0.282173	0.3757	0.6129
2			2.8833		0.1601	0.256320		
3			2.9125		0.1893	0.358345		
4			2.0809		-0.6423	0.412549		
5			2.4846		-0.2386	0.569299		
6	Sedimentary	Shale	2.6200	2.5052	0.1148	0.131790	0.1317	0.3629
7			2.4285		-0.0767	0.005883		
8			2.4428		-0.0624	0.003894		
9			2.3571		-0.1481	0.219336		
10			2.6777		0.1725	0.297562		

Table 3. Mean density of Hawul rocks / standard density

S/N	Specific rock type	Mean Density (g/cm3)	Range (g/cm3)	Standard density (g/cm3)
1	Gabbro	2.32 ± 0.72	1.8125 – 2.5642	2.3 – 3.0
2	Basalt	2.41 ± 0.29	2.0266 – 2.5333	2.4 – 3.3
3	Sandstone	2.21 ± 0.59	1.7625 – 2.5333	2.2 – 2.8
4	Granite	2.27 ± 0.61	2.0809 – 3.2545	2.6 – 2.7
5	Shale	2.50 ± 0.36	2.3571 – 2.6777	2.4 – 2.8

Conclusion

The densities of the different specific rock types within Hawul area have been characterized. The mean densities of these rocks are as follows; gabbro (mean ρ~2.32±0.72 g/cm^3), basalt (mean ρ~2.41±0.29 g/cm^3), sandstone (mean ρ~2.21 ±0.59 g/cm^3), granite (mean ρ~2.27±0.61 g/cm^3) and shale (mean ρ~2.50±0.36 g/cm^3). The densities of Hawul rocks as compared to the standard values could imply to have originated from the same parent material. Since the density of rocks vary significantly among different rock types because of differences in mineralogy and porosity, the knowledge of distribution of underground rock density should be improved and encouraged to help in finding the subsurface geologic structure and rock type that would be essential for building and construction.

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