Asian Journal of Advanced Research and Reports

3(2): 1-6, 2019; Article no.AJARR.46959

Assessment of Magnetic Susceptibility of Some Selected Rock Samples from Karu Area, Northcentral Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author TOA designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors GGN and KA managed the analyses of the study. Author MU managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJARR/2019/v3i230085
Editor(s):
(1) Dr. Juan Manuel Vargas-Canales, Professor, Department of Social Studies of the Division of Social and Administrative Sciences, University of Guanajuato, Mexico.
Reviewers:
(1) Nordiana Mohd Muztaza, Universiti Sains Malaysia (USM), Malaysia.
(2) Snehadri B. Ota, Institute of Physics, Bhubaneswar, India.
(3) Saleh Ibrahim Bute, Gombe State University, Nigeria.
Complete Peer review History: http://www.sdiarticle3.com/review-history/46959

Original Research Article

Received 19 November 2018
Accepted 28 January 2019
Published 16 February 2019

ABSTRACT

Magnetic susceptibility is a very sensitive indicator of magnetic minerals present in rock because any slight variation in magnetic mineralogy is usually reflected by a profound change of susceptibility. However, the knowledge of its mineral composition does not provide adequate information about the rock and mineral composition of rock and properties such as magnetic susceptibility determines the property of rock. Six samples of the rocks were obtained at different two quarries site each located at Nyanya and Karu for the assessment of magnetic susceptibility which were measured with an instrument called magnetic susceptibility meter EM2S+. The results obtained shows that limestone has low magnetic susceptibility compared to other rock samples such as pegmatite, quartzite, gneiss, granite, granite gneiss, sand stone in both site and pegmatite has the low magnetic susceptibility compared to other rock samples in Karu. The average magnetic susceptibility of the rock samples from Nyanya and Karu are 4.11 x 10^{-4} (SI) and 4.99 x

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10^{-4}(SI) respectively. In conclusion, the selected rock samples show that granite gneiss > laterite > sand stone > granite > gneiss > quartzite > pegmatite > limestone. Which indicate that limestone has the low magnetic susceptibility than other rock samples, show the present of Felsic materials while granite gneiss has a very high magnetic susceptibility, as a result of the present of large amount of iron and magnesium in it.

Keywords: Granite; laterite; limestone; magnetic susceptibility; sand stone; pegmatite; quartzite.

1. INTRODUCTION

Geological maps of an area give general information about the type of formation or rock units that exist in the area. The comprehensive nature of this depends on the scale of the maps. However, there is a limit to the type of information that can be extracted from geological maps because of the complex mechanism of geomorphology [1,2,3]. Hence, for detail study of an area especially with the view to producing scientifically based for provision of social infrastructures, additional method like drilling and geophysical technique are necessary and complimentary because they pick up other details which are usually not available in geophysical maps [4,5,6,7]. Rock or stone is a natural substance, a solid aggregate of one or more minerals or mineraloids. the Earth's outer solid layer, the lithosphere, is made of rock. These include igneous rocks, metamorphic rocks and sedimentary rock. Rock generally consists of magnetic properties which are measure by an instrument called magnetometer [2]. Due to these magnetic properties, rocks are mostly susceptible to be magnetized. Susceptibility is the degree to which a rock sample is magnetized. Magnetic anomalies are caused by magnetic minerals mainly Magnetite and pyrrhotite contained in rocks. Studies of the magnetic history of the earth crust shows that the earth`s field has varied in magnitude and has reversed its polarity a couple of times [8,9,10]. Magnetic susceptibility is the measure of the ease with which a rock sample is magnetized when subjected to magnetic field. The ease of magnetization is related to the concentration and composition (size, shape and mineralogy) of the magnetizable mineral content of the rock sample [11,12,13]. Magnetite for example, account for most of the susceptibility observed in rocks. Thus, the measurement of susceptibility can be done before magnetic survey take place to determine which rock will be detectable magnetically and to what extent. The measurement can be performed in the field on outcrop or on samples in laboratory. Magnetism is a vector quantity whose magnetic anomaly is produced by the contrast between the intensity and direction of magnetization of the disturbing mass and that of the surrounding rock material. Magnetization is composed of induced and remnant vector. The former depends on the susceptibility of the magnetic material present and the strength of the ambient geomagnetic field. The latter is of permanent nature and depends on the type and amount of magnetic material present in the rock and on its magnetic history [14,15,16]. Mineral composition of rock and properties such as magnetic susceptibility determine the property of rock, about these demands, the aim of this investigation is to look at the assessment of magnetic susceptibility of some rock at Karu Local Government Area Council, Nassarawa State, Northcentral, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

The study area is Nyanya and Karu in karu local government area council of Nassarawa state is bounded by latitude 8°30'00"N and 8°15'00"E as show in Fig. 1. The major soil units of Nassarawa state belong to the category of oxisols or tropical ferruginous soils. The soils are derived mainly from the basement. Lateritic crust occurs in extensive areas on the plains. While hydromorphic soils (humic inceptisols) occur along the flood plains of major rivers. The rocks sample were obtained from Reynolds and Nkefred quarries site located at Nyanya and Karu respectively, fresh outcrop of the sample was obtained after blasting the rock into various sizes. Six rocks samples were obtained from both Reynolds and Nkefred quarries respectively.

2.2 Experiments Design

The rock samples were obtained from two quarries sites namely Reynold quarry site located at nyanyan and Nkefred quarry site located at Karu. Fresh outcrops of the samples were obtained by driving a chisel into the rock using a hammer; six samples of the rocks were obtained

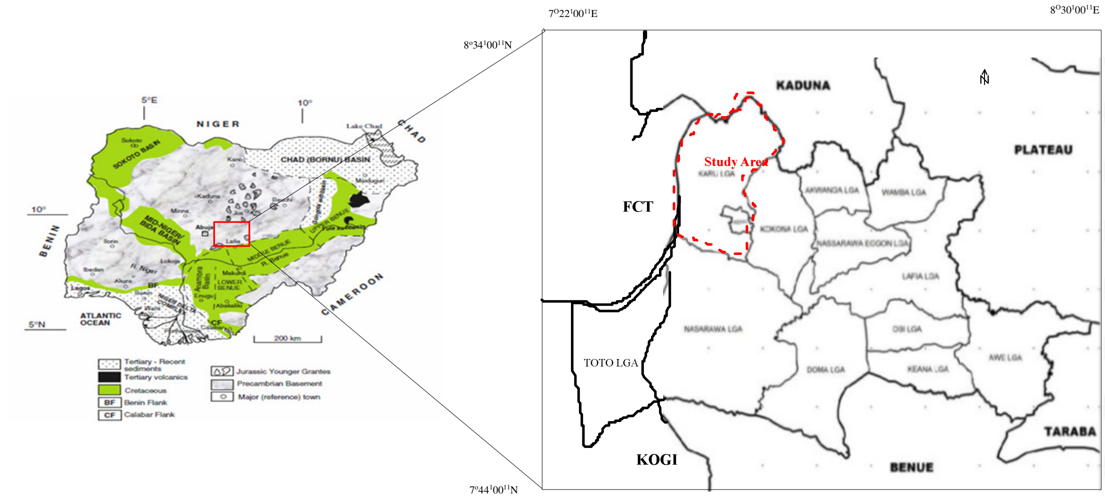

Fig. 1. Geological map of Nigeria and study area

at both sites each. These samples were taken to National Geosciences Research Laboratory Centre in Kaduna for identification and analysis using an instrument called magnetic susceptibility meter EM2S+. The EM2S+ is an accurate geophysical instrument use to detect the magnetic susceptibility of a rock. To obtain the stability of the base values which should be around zero (0) and in order to avoid a drift of the signal, the probe and the dell leave ON for one hour before taking the first measures. After the one hour's delay, re-initialize the probe measures are then taken. But if you wanted to take measurements right away after turning on the probe, initialize the probe every minute or, for best results, before each reading for the first 30 to 60 minutes. This preventive procedure decreases the risk to take erroneous values that would be caused by weather variations or by other external causes and lead to a drift of the instrument. It is therefore very important to often re-initialize in order to maintain the zero (0) base value used in the calculation of the displayed values. The identification was carried out in the Geographical Laboratory after label sample were taken to Geophysics Laboratory for the susceptibility analysis of measurement. Magnetic susceptibility meter was first raising up in the air about one meter (1 m) away from the sample to take the air reading after which it was placed on the sample for magnetic susceptibility measurement were taken on each sample and susceptibility on each sample determined. After the last magnetic susceptibility measurement on each sample, air reading was taken again. The mean of the first and second air reading were then calculated and subtracted from the mean magnetic susceptibility of the sample. This is to ensure that the interference errors were reduced as much as possible. This procedure was repeated for the entire selected samples both from Reynolds and Nkefred site respectively, as shown in Fig. 2 and Fig. 4.

3. RESULTS AND DISCUSSION

From the analysis, Figs. 2 and 3 shows that the limestone has the lowest magnetic susceptibility value of 0.140 x 10^{-3} which is 6% while one of the granite has the highest magnetic susceptibility value of 0.620 x 10^{-3} which is 25%, compare to other two (2) granite with magnetic susceptibility value of 0.320 x 10^{-3} which is 13% and 0.385 x 10^{-3} which is 15% respectively, follow by sandstone with magnetic susceptibility value of 0.490 x 10^{-3} which is 20%, and laterite with magnetic susceptibility value of 0.515 x 10^{-3} which is 21%. This result agrees with those of earlier studies Which says that low susceptibility in samples is as a result of the presence of Felsic materials found in the rocks which are silica – rich with small amount of the oxides of Calcium, Magnesium and Iron such as George and Priscillia [2], Abon and Osazuwa [5], Aydin [12], and Holger et al. [17].

From the Figs. 4 and 5 the pegmatite has the lowest magnetic susceptibility value of 0.170 x 10^{-3} which is 6% while one of the granite gneiss has the highest magnetic susceptibility value of 1.110 x 10^{-3} which is 37%, compare to other two (2) granite gneiss with magnetic susceptibility values of 0.350 x 10^{-3} which is 12% and 0.910 x 10^{-3} which is 30% respectively, quartzite follow the lowest with magnetic susceptibility value of 0.205 x 10^{-3} which is 7%, and gneiss with magnetic susceptibility value of 0.250 x 10^{-3} which is 8%.

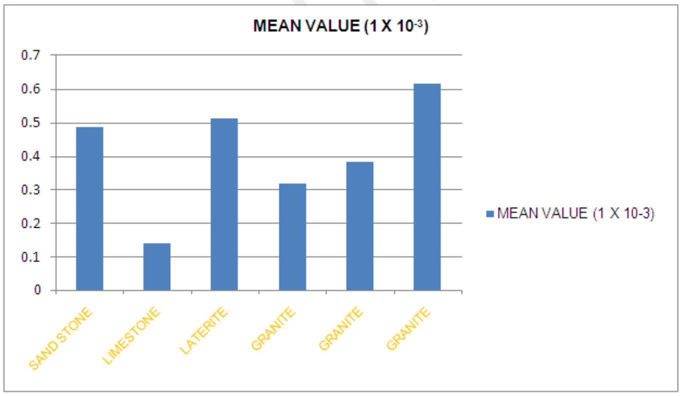

Fig. 2. Bar chart shows the assessment of magnetic susceptibility of rocks in Reynold Quarry (Nyanya)

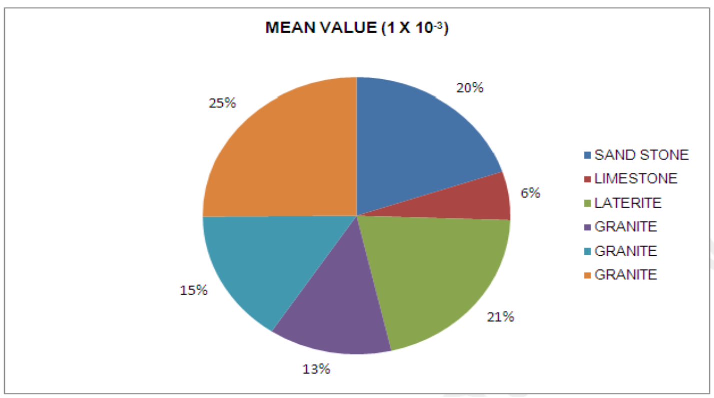

Fig. 3. Pie chart shows the % assessment of magnetic susceptibility of rocks in Reynold Quarry (Nyanya)

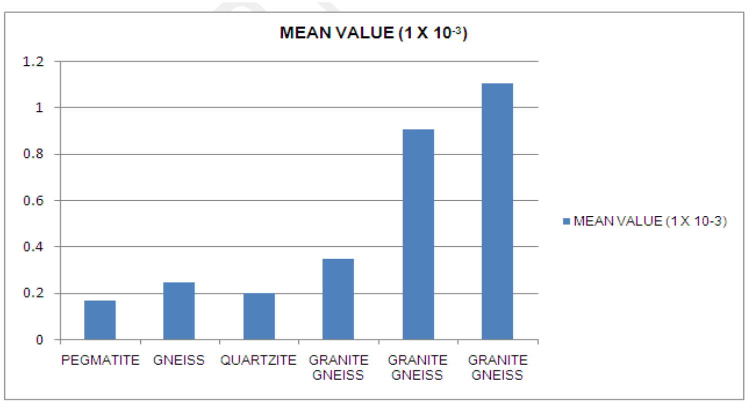

Fig. 4. Bar chart shows the assessment of magnetic susceptibility of rocks in Nkefred Quarry (Karu)

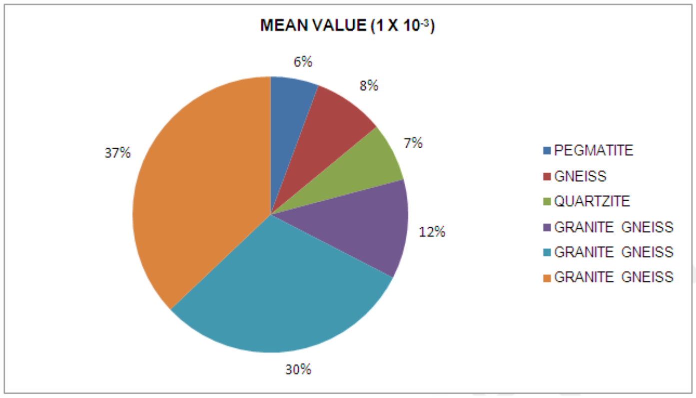

Fig. 5. Pie chart shows the % assessment of magnetic susceptibility of rocks in Nkefred Quarry (Karu)

In summary, it is found that limestone has low susceptibility value 0.140 x 10^{-3}, follow by granite 0.320 x 10^{-3}, granite 0.385 x 10^{-3}, sandstone 0.490 x 10^{-3}, laterite 0.515 x 10^{-3} and granite with the high value 0.620 x 10^{-3} as was analyzed in the selected rock samples from Reynold Quarry site in Nyanya. It is also found that pegmatite has low susceptibility value 0.170 x 10^{-3}, follow by quartzite with 0.205 x 10^{-3}, gneiss with 0.250 x 10^{-3}, granite gneiss with 0.350 x 10^{-3}, granite gneiss with 0.910 x 10^{-3} and granite gneiss with the high value 1.110 x 10^{-3} has been analyzed in the selected rock samples from Nkefred Quarry site in Karu. The graphical representation shown in Figs. 2 to 4 in both locations Reynolds and Nkefred quarries, shows that limestone has the lowest magnetic susceptibility than other rock samples, this is as a result of the presence of Felsic materials found in the rocks while granite gneiss has a very high magnetic susceptibility, this is as a result of the presence of large amount of iron and magnesium present in the sample.

4. CONCLUSION

In this paper, we found that the average magnetic susceptibility for the sample of rocks from Nyanya is 0.412 x 10^{-3} and those from Karu is 0.499 x 10^{-3}. The result shows that rock with low magnetic susceptibility were found with Felsic materials while high magnetic susceptibility is as a result of large amount of iron and magnesium present in those samples.

ACKNOWLEDGEMENT

The profound gratitude goes to Prof. I.I.Y Mallo of Geography Department, University of Abuja, who helped in identifying of the rock samples, Mr. Arobasalu Ojo, Thaddeus and Mrs Grace Okpala from National Geosciences Research Laboratories Centre Kaduna, they took time to examine and measure the susceptibility of the rock samples thanks.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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