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Identification of Mineral Deposits in Garin Awwal Mining Site, Kebbi State, North-Western Nigeria

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Abstract- **Minerals are chemical elements and compounds that have been formed through inorganic processes. The economic importance of these minerals paved a way for researches in the related areas. The aim of the research is to determine the mineral deposits in the study area (Garin Awwal). The study area lies in north-western Nigeria between Lat. 10°23'28'' and 12°26'24''N and Long. 03°53'08'' and 06°38'18''E. The results obtained from the research work show different kinds of minerals available in the study area. Different measurements were made and the obtained results were recorded accordingly. These are density, resistivity/conductivity and thin section preparation. It has been observed that, some densities and resistivity values are close to others and hence are expected to have some common geologic features and minerals compositions. The densities recorded are 27.11, 68.55, 65.00 and 27.01 kg/m^3 for samples 1, 2, 3 and 4 respectively. The resistivity values are 6.77×10^{17}, 1.92×10^{-7}, 1.72×10^{-7} and 7.10×10^{2} Ωm for samples 1, 2, 3 and 4 respectively. In the other hand, the thin section results show the presence of quartz, iron ore, feldspar, goethite, feldspar, goethite and some metallic elements (e.g. aluminium and copper), and opaque minerals (e.g. columbite, magnetite, chromite etc.). Further research is recommended in the study area to determine the quantity and quality of minerals available. Proper harnessing of these mineral resources could boost the economy of the state and Nigeria in general.**

Keywords—Mineral Deposits, Thin section, Micrographs, Resistivity/Conductivity

I. INTRODUCTION

Minerals are naturally occurring inorganic solids with a definite chemical composition and a definite physical structure. Many minerals are readily identified by their physical properties but identification of other minerals may require instruments designed to examine details of their chemical composition or crystal structure (James, 1999). Earth's crust is the source of a wide variety of useful and essential substances. In fact, practically every manufactured products contains substances derived from minerals. Examples of some metallic minerals are aluminum, chromium, copper, gold, iron, lead, magnesium, manganese, mercury, molybdenum, nickel etc.

Minerals resources are the endowment of useful minerals ultimately available commercially (Reyment, 1965). Resources include already identified deposits from which minerals can be extracted profitably, called reserves, as well as known deposits that are not yet economically or technologically recoverable. Deposits inferred to exist but not yet discovered are also considered as mineral resources. In addition the term ore is used to denote those useful metallic minerals that can be mined at a profit. In common usage the term ore is applied to some non-metallic minerals used for such purpose as building stone, road aggregate, abrasives, ceramics and fertilizers are not usually called ores; rather they are classified as industrial rocks and minerals (Hanna, 1969).

Clay deposits are abundant in Kebbi state. A section of kaolinitic clay within the Illo formation, termed "pisolitic clay member" has been described by (Macleod, 1964). Acccording to Jones (1948), the deposit was originally investigated for its high alumina content but no bauxite was found. The pisolitic clay of the Illo formation extends over 100 kilometers from the international boundary near Kamba to Libba on the contact with the basement. The average thickness of the bed is 3 meters, with a maximum of six meters north-northeast of Dakingari. Over large areas, the composition is that of relatively kaolin with a small excess of alumina and less than 1% iron oxides. Tests carried out on selected samples showed them to have refractoriness in the intermediate heat duty range (Kogbe, 1979).

According to Kogbe (1989), clays are also abundant in Dange, Kalambaina as well as Gamba formations. They also occur abundantly in the lower Gwandu formation, as in Kwondomo village about 10 kilometers south of Illela on the Sokoto road. In these Gwandu formations, clays are white in color and often occur as nodules or roundish (balls) indicating some local turbulence in the depositional environment. It could however be possible to exploit most of the Illo and Gwandu formation clays as the basic raw materials for a ceramic industry, whereas the clays or shale of the Sokoto group of sediments are already being utilized in the manufacturing of cement at the Sokoto cement factory. This application however is limited as the Kalambaina limestone is often quite shale.

Parker (1964), disclosed that, the sediments of the Sokoto area confirmed the existence of gypsiferouss horizons in two different formations and he renamed them respectively as Dukamaje formation and Dange formation, the latter was assigned to the Paleocene. In recent years the establishment of a cement factory, both in Malbaza (Niger Republic) and in sokoto has produced a market for local gypsum, which is extracted in the form of local pitting by the inhabitants of the Rima valley (Berggren, 1974). Reyment (1965), stated that, between 1967 and 1969, an investigation of the gypsiferous horizons of the Dukamaje formation was carried out and a hill southwest of Taloka was chosen as a type deposit. Seven trenches were made and gypsum was separated from the material extracted and analyzed. Additional information was obtained from paleontological excavations prompted by the discovery of several vertebrate fossils at various levels of the Dukamaje formation.

Pisolitic and oolitic ironstone bands are frequently in the Gwandu formation. These are most probably reworked from the Paleocene oolitites overflying the sokoto group of sediments. Some of them have been exploited in the past as at Aliero. Thickness of up to 13. 7 meters have been recorded and the best out – crops are found in the south of Brinin – Kebbi. They are exposed along the valley of the Dangwaremi River from Maiyama to Kalgo and Koko. The iron content of the ironstone from near Kalgo varies from 47 to 53 % while the P_20_5 content is about 2.6% (Falconer, 1911).

In the southern part of kebbi is a schist belt where the study area is located and is called Zuru Schist Belt which also attracted many researches among which is Udoh (1987), who reported that the Zuru Schist Belt consist of assemblage of muscovite-biotite banded gneisses, porphyroblastic gneisses, migmatites, schists, quartzites, metavolcanics (amphibolites), Older Granites and minor rocks such as gabbro, andesite, granulites and calc-silicates. Adefila (1966), noted the occurrence of quuartzites, mica schists, granulites and calc-silicates rocks in the area in which the schist belt is part. Danbatta (2005), identified a number of structural elements in Zuru Schist Belt. He pointed out three major NNE-SSW to NE-SW trending Yelwa, Yauri and Ribah dextral faults, a NW-SE trending Gunu sinistral fault and a major N-S trending anticlinorium called the Zuru anticlinorium.

Danbatta (2008), reported the Zuru Schist Belt as a schist lithologically different from the other schists belt in northwestern Nigeria and that it is predominantly composed of quartzites with very surbodinate schists and amphibolites. The Zuru area contains two crustal blocks that were formerly separated by an unknown distance and became welded together during the Pan-African aggregation. The boundary between these blocks is now represented by the major NE-SW shear zone that crosses the Zuru Sheet (Ajibade and Wright, 1989).

Turner (1983), and Ajibade *et al*. (1987) identified and classified eleven main schist belts in the northwestern and north-central parts of Nigeria. These are the Birnin Gwari, Kushaka, Wonaka, Zuru, Anka, Maru, Malumfashi, Kazaure, Illesha, Igarra and Isenyi-Oyan schist belts. Turner in (1983), went further to report that, the Zuru and Kushaka belts were also considered to have formed in a separate basin; with the Zuru quartzite's representing basin margin deposits. That the Anka fault system in Zuru belt and Ifewara fault system have ensimatic affinities, thus the Anka and Zuru belts are considered as a pair of belts that evolved through ensimatic processes. Garba (2003), reported that the gold mineralization is present in alluvial and eluvial placers and primary veins from several parts of schist belts in the northwest and southwest of Nigeria.

Ajibade *et al*., (1987) clarified that, the Zuru Schist Belt, like other schist belts has been deformed and metamorphosed and comprises of three rock units namely: quartzites, muscovite schist and medium grained granites. The oldest rock unit within the schist is the muscovite schist which was derived from previously existing sedimentary sequence of possibly Eburnean age that have been deformed and metamorphosed. The mineralogical assemblages of the rocks in Danko area (part of Zuru Schist) are quartz, micas (muscovite and biotite), chlorite, sillimanite, garnet for the quartzites; quartz, muscovites, biotite, chlorite for the muscovite schist and quartz, biotite, microcline, perthite, sericite for the medium grained granite (Umaru, 2016).

A. Study Area

Kebbi State is located in the North-Western part of Nigeria with its capital at Birnin Kebbi. It is bordered by Sokoto State, Niger State, Zamfara State, Dosso Region in the Republic of Niger and the nation of Benin. It has a total area of 37.418.km² and a population of 3,256,541 at the 2006 census (Aduojo *et al.*, 2018). The study area lies in north-western Nigeria between Lat. $10^0$23'28'' and $12^0$26'24''N and Long. 03^o53'08'' and $06^0$38'18''E (Fig. 1). It is located in Fakai local government area of Kebbi state and is accessible through Abuja, the Federal Capital Territory, via Minna – Kontagora – Zuru – Mahuta – Garin Awwal. The mining site is located in the north-western part of Garin Awwal almost two (2) km away.

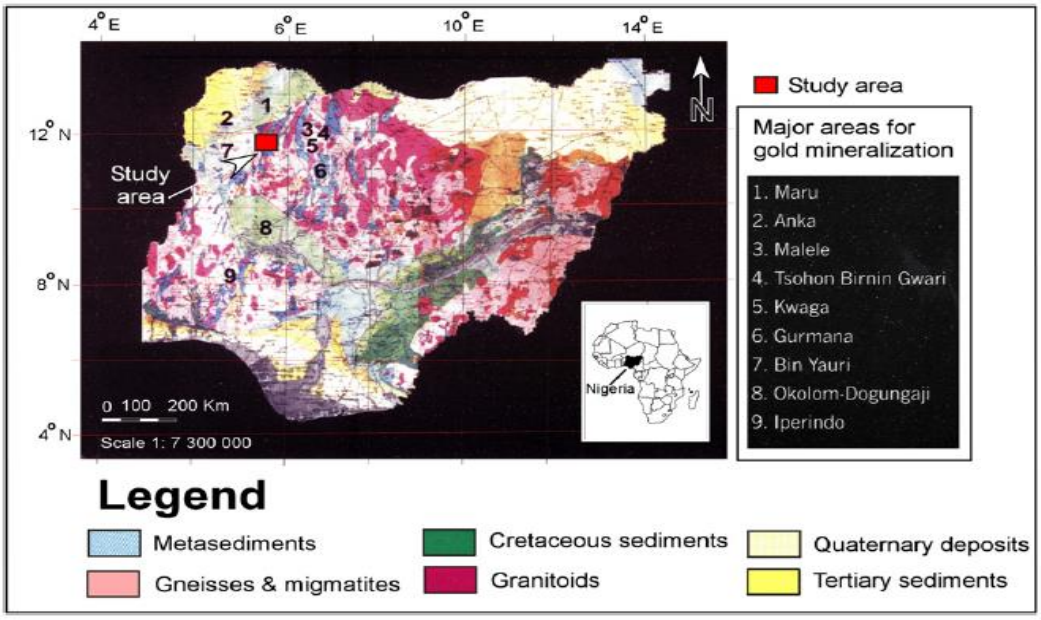

Fig. 1: Geological map of Nigeria showing the major areas of gold mineralization and location of the study area (Talaat and Mohammed, 2010).

II. MATERIS AND METHOD

A. *Materials and equipment*

In this research, the materials and equipment used are hammer and digger (sample collection), measuring cylinder, water, triple beam balance (density measurement), pestle and mortar, HP 4275A multi-frequency LCR meter (conductivity/resistivity measurement), hammer compasses, mounting machine, cutting machine, silicon carbide, glass plate, pale of water, rock sample, epoxy resin, hot plate, micro trimming machine, chip, glass slide, microscope, chromatic, razor blade and cover slip (Thin section).

B. *Methods*

The method was by collection of samples (rocks) from the study area and experiments were performed to reflect the literature of the previous findings. The conducted experiments are density and resistivity/conductivity measurements and mineral content analysis using thin section preparation.

C. *Preparation*

The collected samples were washed thoroughly and dried to remove the unwanted dust. The volume and mass of the samples were measured directly using the measuring cylinder, water and triple beam balance from which their densities are calculated. For the conductivity/resistivity measurement, the samples were grinded using a mortar and pestle to the finest level and the powder was sieved for uniformity. The powdered samples are made in the form of pellets (rectangular shape with a thickness of 3 mm) using a hydraulic press and sintered in a muffle furnace at a temperature of 1000-1100 K. The pellets are then used for conductivity/resistivity measurement. While for the thin section preparation, the samples were sliced using the rock cutting machine with diamond-saw to the desired thickness and chips of rectangular shapes were produced. The chips were then taking for thin section preparation.

III. RESULTS AND DISCUSSIONS

3.1 Density

The result obtained from density measurement is shown in table 3.1.

TABLE 3.1 RESULT OF THE DENSITIES OF MINERALS

Sample	Density (Kg/m$^{3)}$
1	27.11
2	68.55
3	65.00
4	27.01

The densities of Sample 1 and 4 are 27.11 Kg/m^3 and 27.01 kg/m^3 respectively and are approximately equal to the density of aluminium (27.00 kg/m^3). Alumnium is a sediment of feldspar (aluminium silicate). This gives room for the suspect of the presence of feldspar in the sample. The densities of both Sample 2 (68.55 kg/m^3) and Sample 3 (65.00 kg/m^3) are relatively lower but closed to the density of iron (78.74 kg/m^3) and therefore Iron content was suspected (Pawar *et al.*, 2009).

3.2 Resistivity and Conductivity

The conductivity of the rocks samples is measured from which the corresponding resistivity is obtained. The results obtained from resistivity and conductivity measurement for the samples is shown in Table 3.2.

TABLE 3.2 RESULTS OF THE RESISTIVITY/CONDUCTIVITY OF THE SAMPLES

Sample	Conductivity (S/m)	Resistivity (Ωm)	Temperature (^{0}C)
1	1.48×10^{-18}	6.77×10^{17}	26.3
2	5.21×10^{6}	1.92×10^{-7}	25.6
3	5.81×10^{6}	1.72×10^{-7}	26.4
4	1.41×10^{-3}	7.10×10^{2}	25.9

The resistivity of sample 2 and 3 are 1.92×10^{-7} Ωm and 1.72×10^{-7} Ωm respectively which are higher than the resistivity of iron (1.0×10^{-7}Ωm) at 20^0C as reported by (Ohring, 1995; Griffiths, 1999 and Serway, 1998) but can still give room for suspecting its presence as the values are close. Likewise, the resistivity of sample 1 (6.77×10^{17} Ωm) is relatively low when compared with the resistivity of quartz (7.5×10^{17}Ωm) at 20^0C but the two values remained closed and quartz is therefore suspected. The resistivity of sample 4 (7.10×10^{2}Ωm) is close to the resistivity of silicon (6.40×10^{2}Ωm) at 20^0C which indicates the presence of quarts (silicon dioxide). Though quartz has high resistivity than silicon, this is because silicon is a pure semiconductor and hence will conduct electricity more than its oxide (quartz) (Ohring, 1995; Griffiths, 1999 and Serway, 1998).

3.3 Thin Section separation

The following results were obtained for different samples after thin section preparation.

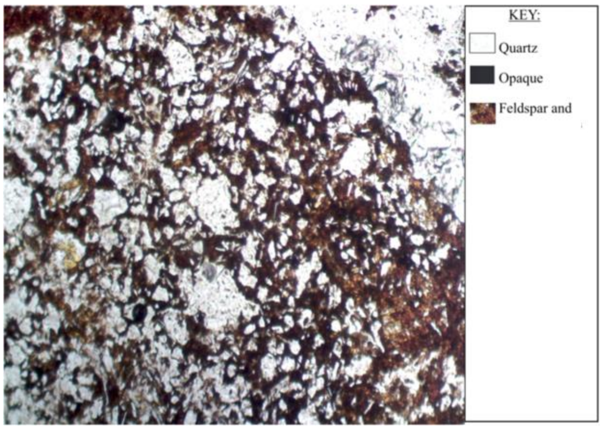

Fig. 3.1: Sample 1 photomicrograph

Fig. 3.1 depicts the photomicrograph of sample 1. It shows that the obtainable minerals in the area are quartz, opaque and feldspar. Some of the dark opaque minerals are suspected to be columbite (niobium iron oxide), magnetite (iron oxide) chromite (iron chromate), energite (copper arsenic sulfide) etc (Talaat and Mohammed, 2010).

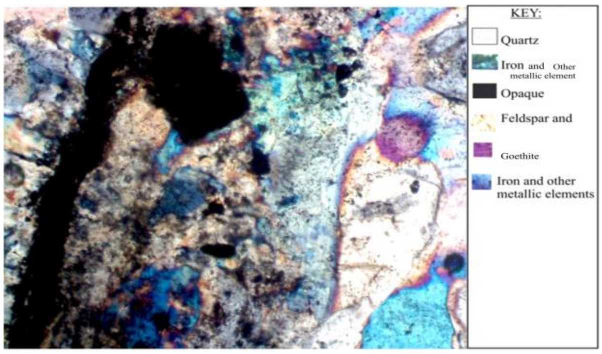

Fig. 3.2: Sample 2 photomicrograph

Fig. 3.2 shows the photomicrograph of Sample 2. It shows that the available minerals that can be obtained from the location are quartz, iron ore, feldspar, goethite, iron and some metallic elements like copper, aluminium and opaque minerals [Columbite (niobium iron oxide), Magnetite (Iron oxide) chromites(iron chromate), Energite (copper arsenic sulfide)] (Garba, 2000).

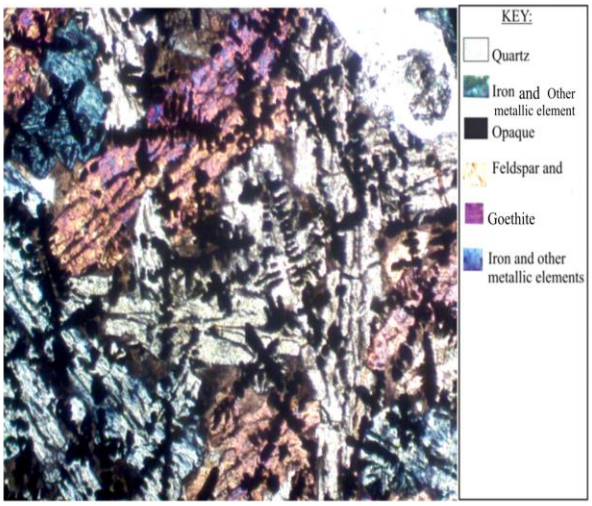

Fig. 3.3: Sample 3 photomicrograph

Fig. 3.3 depicts the photomicrograph of sample 3. It shows that the available minerals that can be obtained from the location are quartz, iron, feldspar, goethite and other metallic elements (copper, aluminum etc). The dark opaque minerals are suspected to be columbite (niobium iron oxide), magnetite (iron oxide) chromite (iron chromate), energite (copper arsenic sulfide) etc (Garba, 2000).

4. CONCLUSION

The results obtained from this research work show the different kinds of the mineral resources available in Garin Awwal. Different measurements were made and the obtained results were recorded accordingly. These are density, resistivity/conductivity and thin section separation. Density measurement was done for each sample. It has been observed that, some densities and resistivity values are close to others and hence are expected to have some common geologic features and minerals compositions. The densities recorded are 27.11, 68.55, 65.00 and 27.01 kg/m^3 for samples 1, 2, 3 and 4 respectively. The resistivity values are 6.77×10^{17}, 1.92×10^{-7}, 1.72×10^{-7} and 7.10×10^{2} Ωm for samples 1, 2, 3 and 4 respectively In the other hand, the thin section results show the presence quartz, iron ore, feldspar, goethite, feldspar, goethite and some metallic elements (e.g. aluminium and copper), and opaque minerals (e.g. columbite, magnetite, chromite etc.).

5. RECOMMENDATION

In view of the economic importance of mineral resources in the development of the Nation, the following recommendations are made:-

i. Government at the Federal, State, and Local level should encourage research work for mineral exploration across the country, particularly in Kebbi State.
ii. Further research is recommended in the study area for determining the quantity and quality of minerals available.
iii. Research institutes should be established in all the states across the federation.
iv. More geoscientists be trained and be specialized on mineralogy.

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