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Original Research

X-RAY DIFFRACTION ANALYSIS OF SOLID MINERAL CONTENTS IN ROCKS OF SONG LOCAL GOVERNMENT AREA OF ADAMAWA STATE, NIGERIA

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ABSTRACT

Solid mineral composition in rocks and soils of Song Local Government Area (LGA) of Adamawa State, Nigeria was investigated. Ten locations were sampled for the study using completely randomized block design (CRBD). The coordinate of each sampling sites were taken. The un-weathered rock samples were collected with chisel and hammer and dried for 12 hours, pulverized and sieved with 150 micro mesh sieves. X-ray diffraction spectrophotometer was used to identify the solid minerals. The results obtained revealed the presence of albite, quartz, microcline, muscovite, orthoclase, phlogopite, biotite, and oligoclase. The minerals reported in the area studied provide basic information for proper planning and exploration.

Keywords: Solid mineral; exploration; X-Ray diffraction; Song LGA; Adamawa State; albite; quartz; microcline

INTRODUCTION

Rocks are aggregate of minerals. Minerals are homogeneous substances that have different composition and have characteristic physical properties such as shape, colour, melting temperature and hardness. The earth's crust is made up of various types of rocks differing from another in mineral content, texture, structure, permeability, mode of occurrence and degree of resistance to denudation (Areola *et al*., 2010). The elements forming the minerals in rocks occur naturally and are stable at room temperature (Osemeahon *et al*., 2015). They are mostly inorganic with a fixed structure (Pipkin and Trent, 2001). The International Logical Association adopted a definition in 1995 for minerals as being elements or compounds that are normally crystalline and has been formed as a result of geological processes (Nickel, 1995). Minerals originate through the processes of rock formation occurring in nature. A common phenomenon accounting for the origin is the cooling of the molten rock material from the earth's interior (magma). The magma that reaches the surface is called the lava and as these minerals crystallize they grow (Pipkin *et al*., 2005).

The search for mineral deposits and hence the art of mineral exploration continued to advance because of the economic benefits derived from mineral deposit to man. This advancement, from early year of twentieth century provided a good opportunity for explorers to look for more effective, less risky and more economical methods of sub-surface mineral exploration. This lead to discovery of different methods of mineral exploration often referred to as geophysical surveying or geophysical exploration techniques. The method is concerned with the investigation of the interior of the earth's surface that is influenced by the distribution of the earth's underground masses. Analysis of the measurements will reveal various properties of the earth's surface (Abubakar and Idowu, 2004). Attempt was therefore made by the researchers to identify the mineral contents in rocks of Song Local government area with X-Ray Diffraction (XRD) technique.

MATERIALS AND METHODS

Materials

X-Ray diffraction spectrophotometer (Empyrean, USA), mortar and pestle, Auger, hammer and chisel, sieve, weighing balance, plastic sample container.

Sampling Locations

The rock samples were collected from ten locations in Song LGA of Adamawa State, Nigeria. The coordinates of the sampling locations were recorded using Dakota 10 Global Positioning System (GPS) as shown in Tables 1.

Table 1: Song Local Government Area Rock Sampling Location Coordinates

Location	Latitude	Longitude
Song	09º49.517'	012º36.833'
Mbila	09º53.830'	012º37.178'
Muleng	09º49.198'	012º43.584'
Mudungo	09º48.907'	012º41.278'
Domayo	09º53.835'	012º35.610'
Sigire	09º56.481'	012º37.855'
Murkumchi	09º50.404'	012º40.957'
Wuromodi	09º50.731'	012º39.436'
Wurotuge	09º49.377'	012º38.890'
Bera	09o49.960'	012º35.572'

Sample Collection and Preparation

About 400g of the rock sample was collected using hammer and chisel to break the un-weathered rocks as described by Magili and Maina (2010). The samples were dried in air for about 12 hours and crushed into smaller pieces and then ground to fine powder using pestle and mortar and sieved with 150 micro mesh sieve. The representative samples for analysis were obtained by coning and quartering technique as explained by Crosby and Patel (1995). This method involves making a cone shape of the sample, flatten it and divide it into four equal parts; two opposite quarters were taken and the other two quarters discarded. This was repeated until the sample was reduced to the size required for final analysis and stored in an air tight container.

X-Ray Diffraction (XRD) Spectrophotometer analysis

X-Ray diffraction spectrophotometer was used for the identification and evaluation of mineralogical contents of the rock and soil samples following the method of Anastasio *et al*. (2017). About 0.35g of the powdered sample was introduced into the sample container and then illuminated with the X-rays. The intensity of the diffracted X-ray will be recorded continuously as the sample and the detector rotate through their respective angles. A peak in intensity will occur when the mineral contains lattice planes with d-spacing appropriate to diffract X-rays at that value of θ. Although each peak consists of two separate reflections (k_1 and k_2), at small values of 2θ, the peak locations overlap with k_2 appearing as a hump on the higher values of θ. Normally these combined peaks are treated as one. Most of the time, the result are presented as position at 2θ and X-ray counts (intensity) in the form of a table or X-ray plot. The intensity (I) can be either presented as peak height intensity, the intensity aboveground or as integrated intensity, i.e. the area under the peak. The d-spacing of each peak will then be obtained by the Braggs equation using appropriate value of λ i.e. $n\lambda = 2d\sin\theta$; n is an integer, the order of reflection. Since all minerals have unique d-spacing, the d-spacing of the unknown minerals obtained were compared with the d-spacing of known minerals for identification (Dutrow and Clark, 2017).

RESULTS AND DISCUSSION

The minerals identified in the rock samples by x-ray diffraction in Song LGA are presented in Table 2. The XRD spectra are presented in figures 1 to 10. Quartz, albite, microcline and muscovite were identified in the rocks of Song (Figure 1). Albite, orthoclase, phlogopite and quartz were observed in the rocks of Mbila (Figure 2). The samples of Muleng showed the presence of albite, muscovite, microcline and quartz (Figure 3). The minerals found in the rocks of Mudungo were albite, microcline and quartz (Figure 4). Among the minerals observed in the rocks of Domayo were albite, microcline, phlogopite and quartz (Figure 5). Albite, orthoclase, microcline and quartz were also found in the rocks of Sigire (Figure

6). The minerals revealed in the rocks of Murkumchi were albite, biotite, microcline and quartz (Figure 7). Minerals detected in the rocks of Wuromodi were albite, microcline, muscovite and quartz (Figure 8). The rocks of Wurotuge showed the presence of albite, muscovite, orthoclase and quartz (Figure 9). The minerals identified in the rocks of Bera were muscovite, oligoclase and quartz (Figure 10). Most of the minerals identified in the rocks of Song LGA were quartz, albite and microcline which are comparable with the results obtained in rocks analysed by Alexander *et al*., (2016).

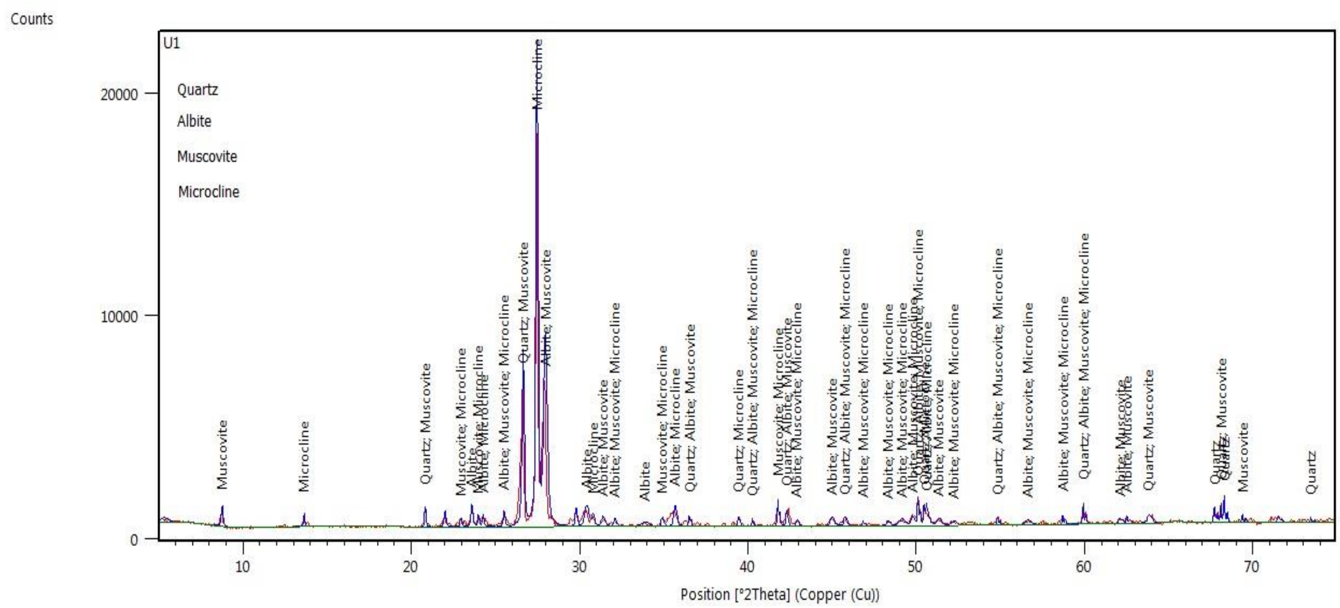

Figure 1: XRD Spectra for Song Rock

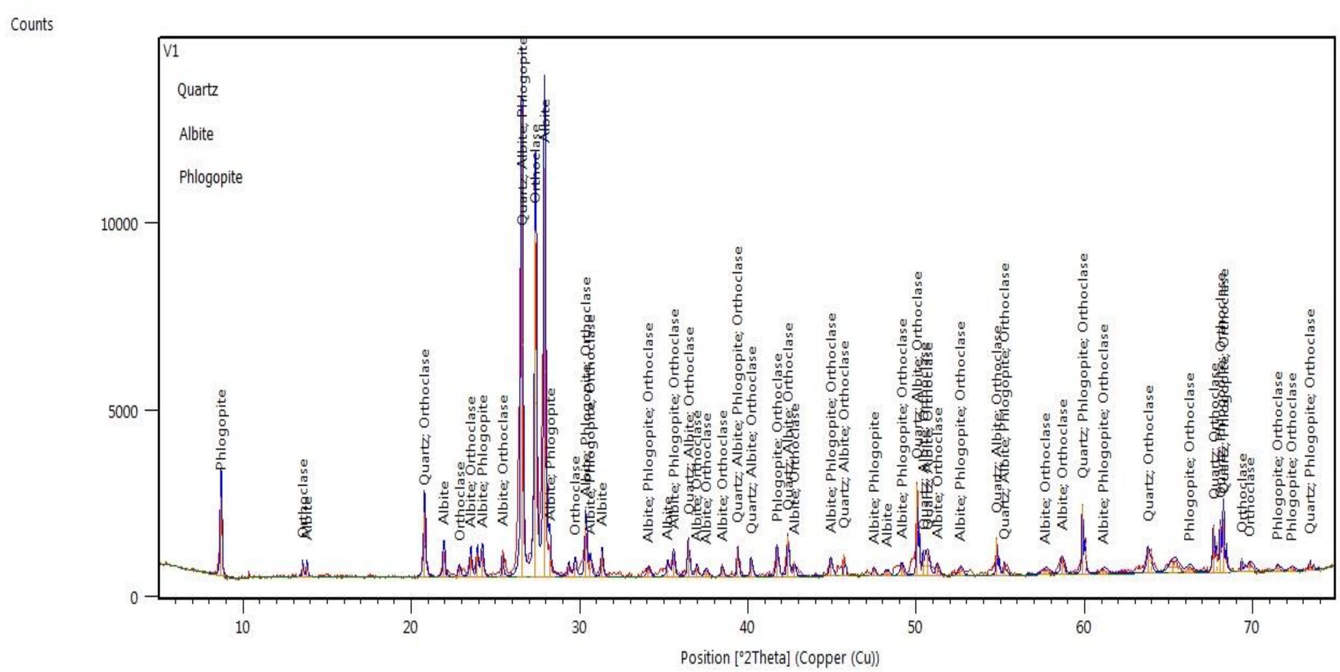

Figure 2: XRD Spectra for Mbila Rock

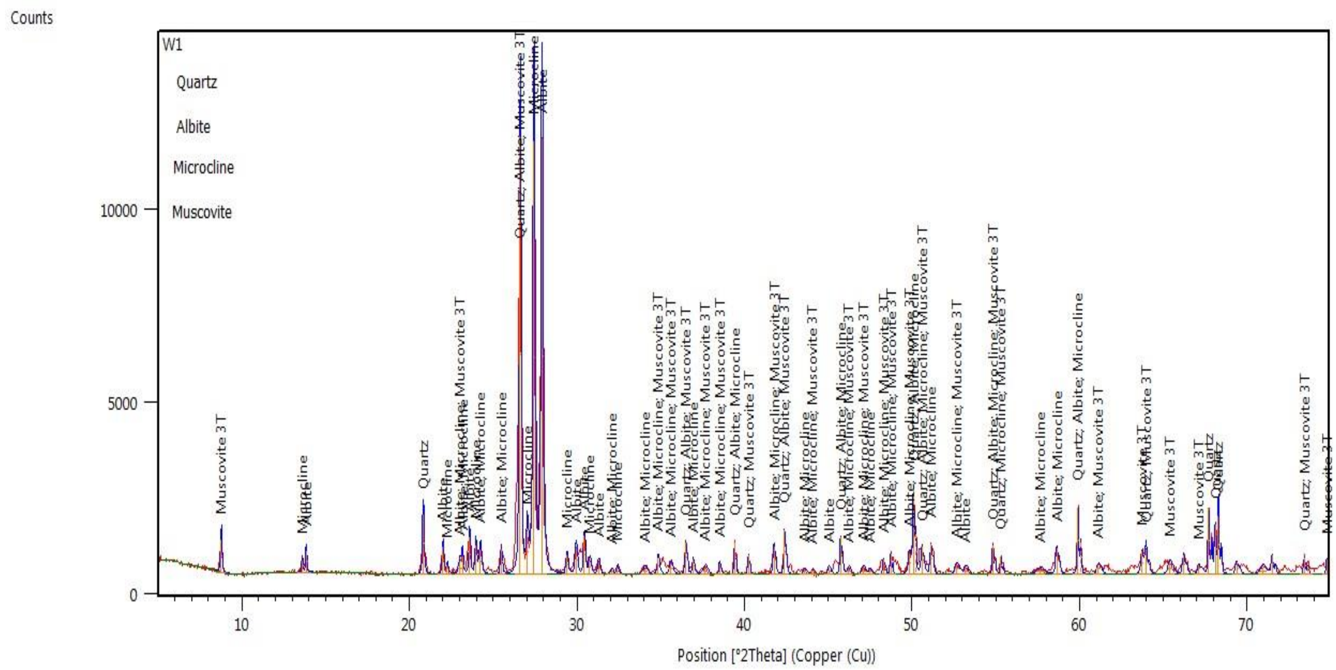

Figure 3: XRD Spectra for Muleng Rock

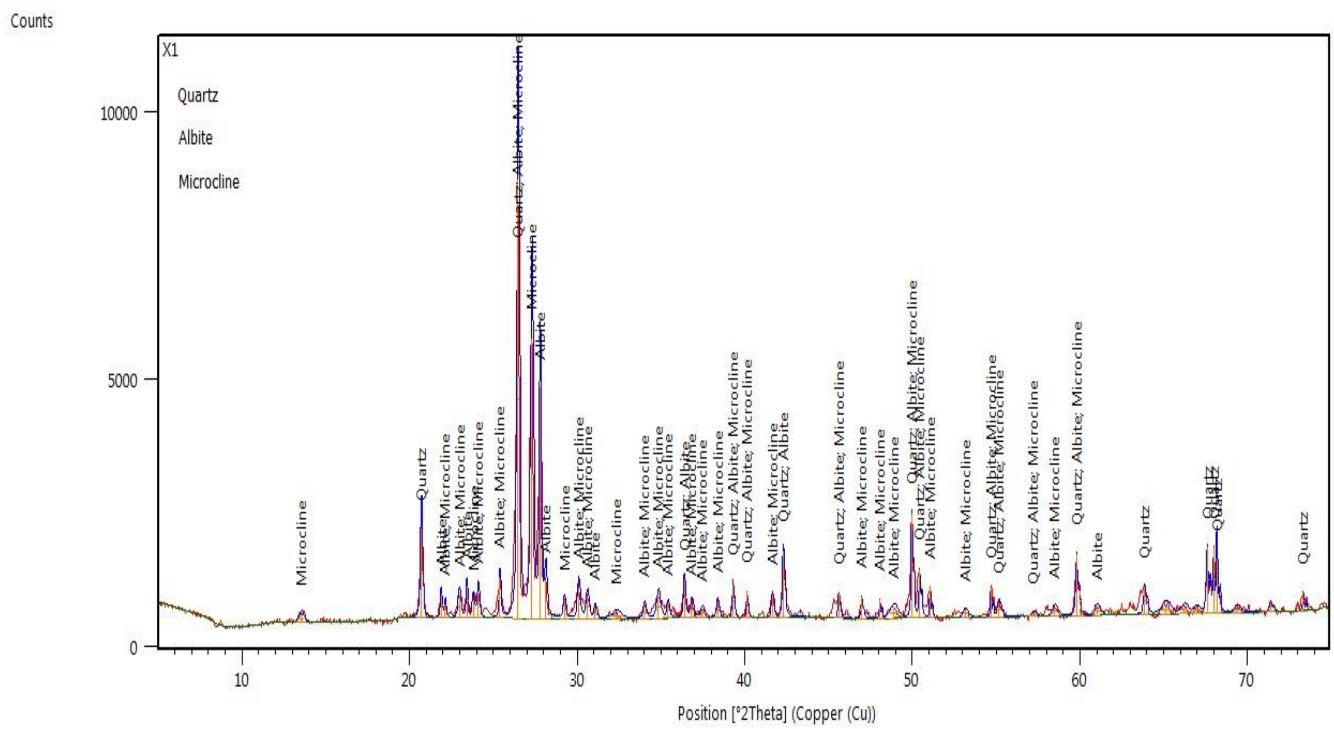

Figure 4: XRD Spectra for Mudungo Rock

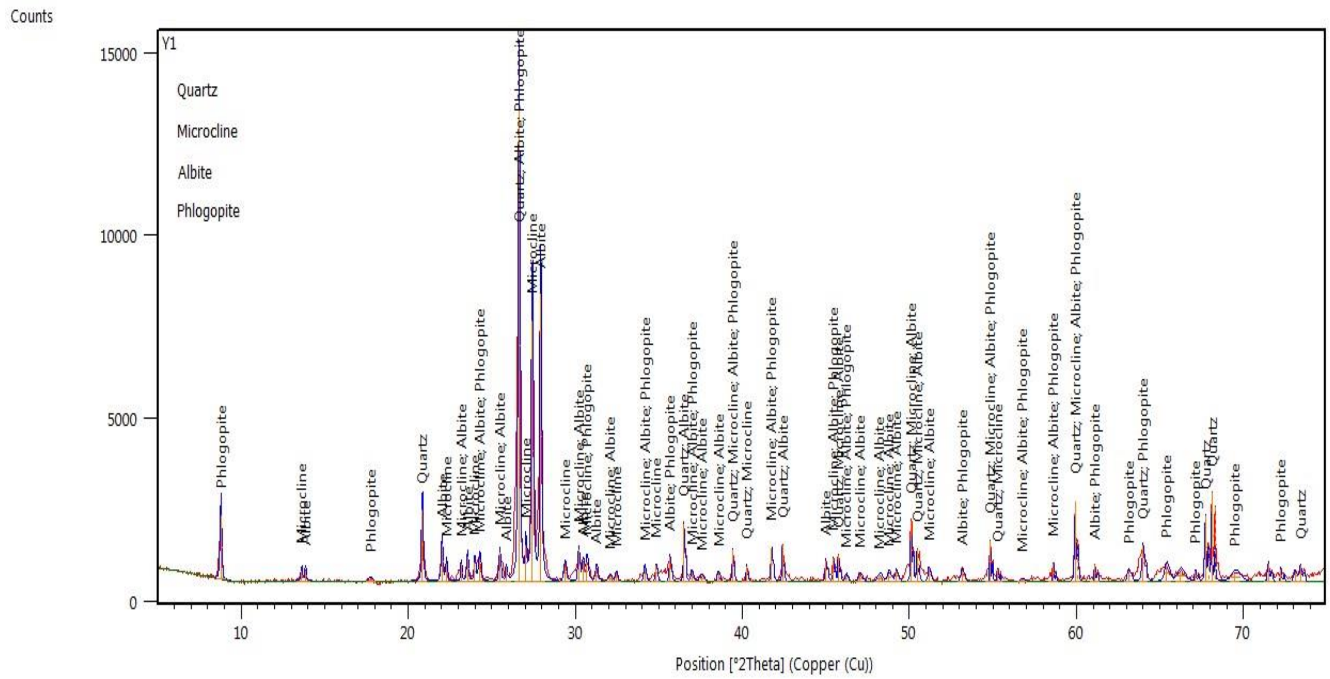

Figure 5: XRD Spectra for Domayo Rock

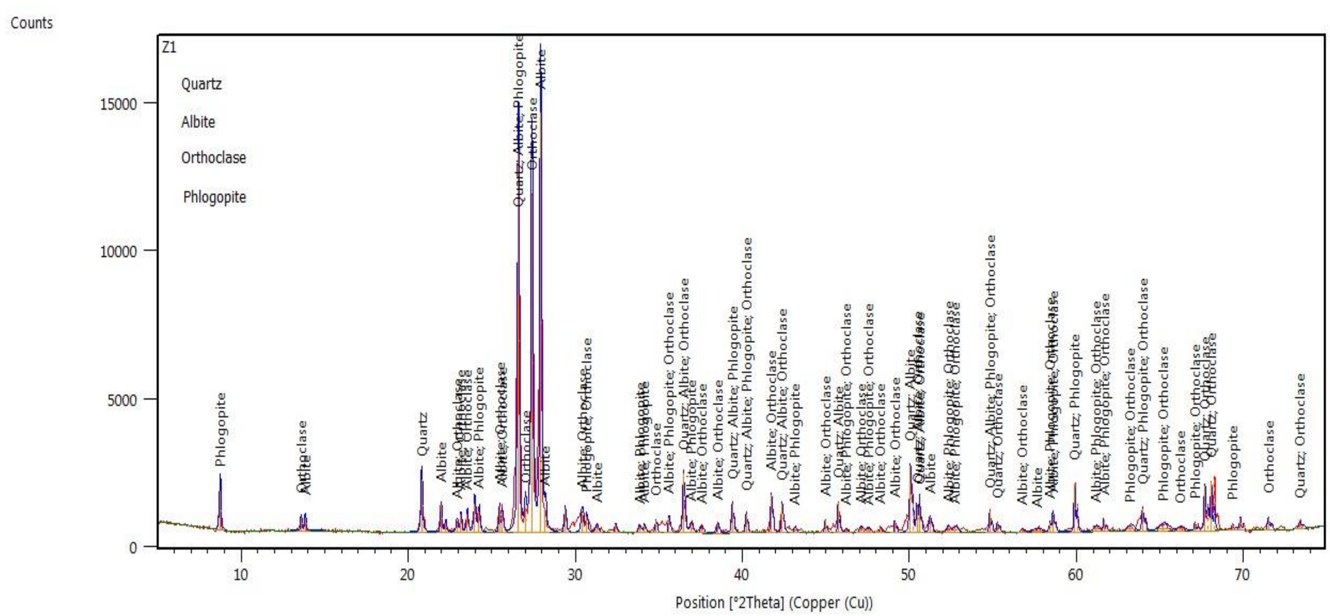

Figure 6: XRD Spectra for Sigire Rock

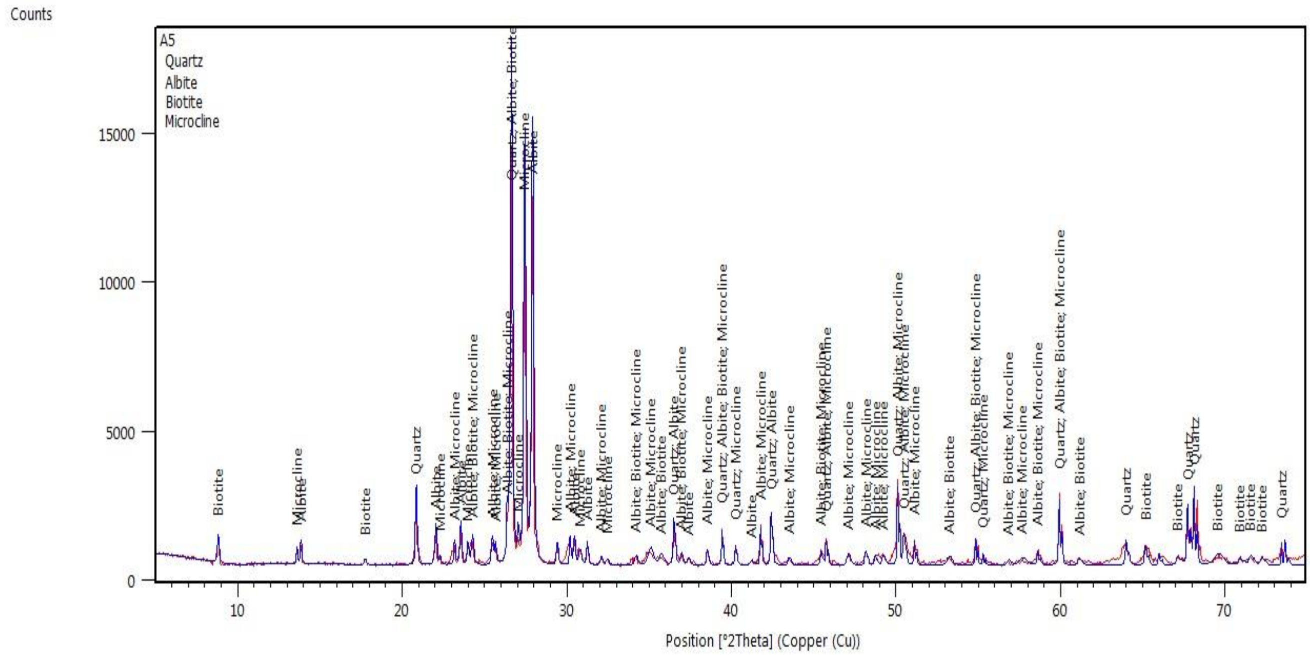

Figure 7: XRD Spectra for Murkumchi Rock

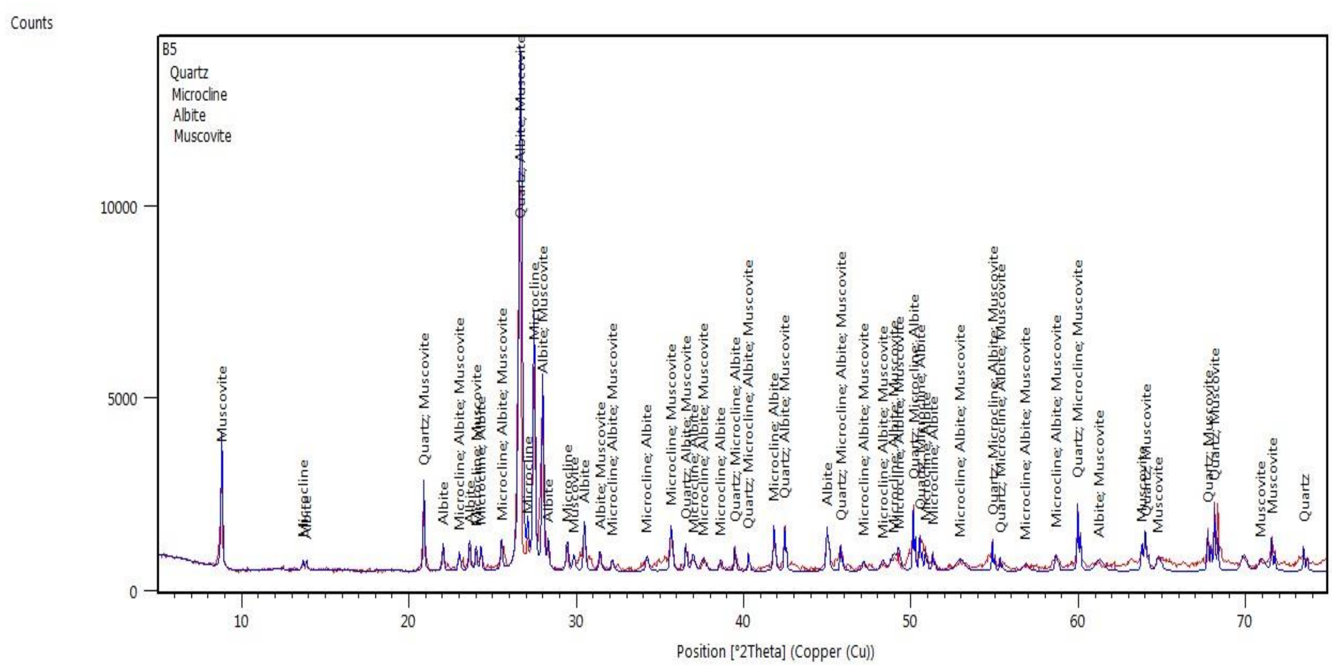

Figure: 8 XRD Spectra for Wuromodi Rock

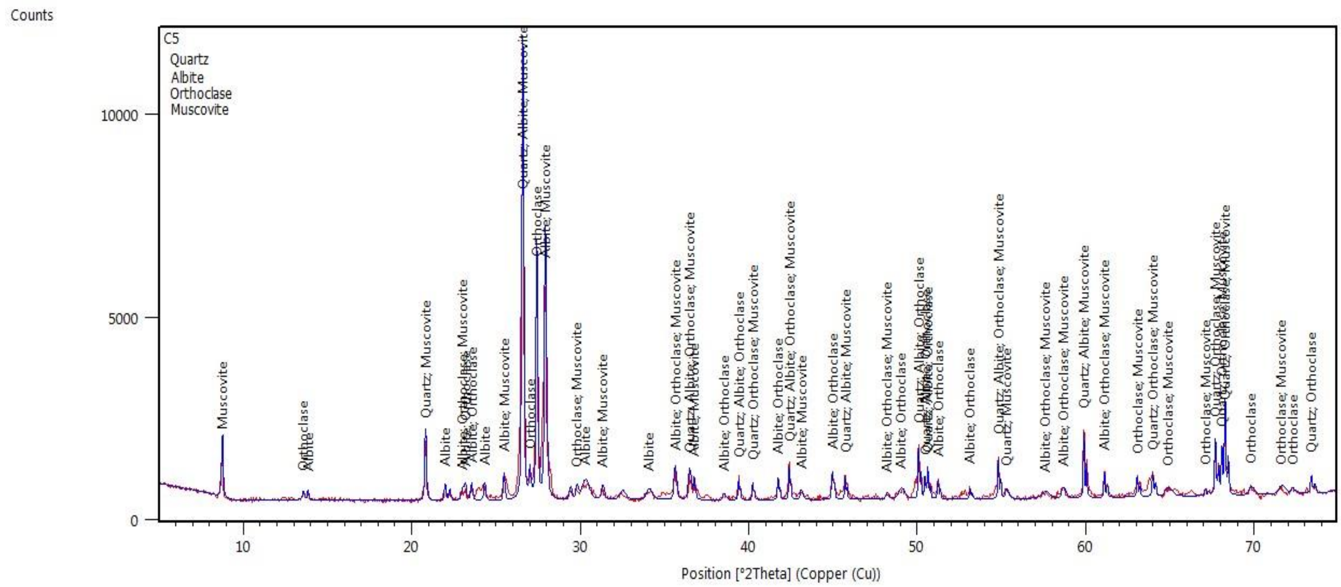

Figure: 9 XRD Spectra for Wurotuge Rock

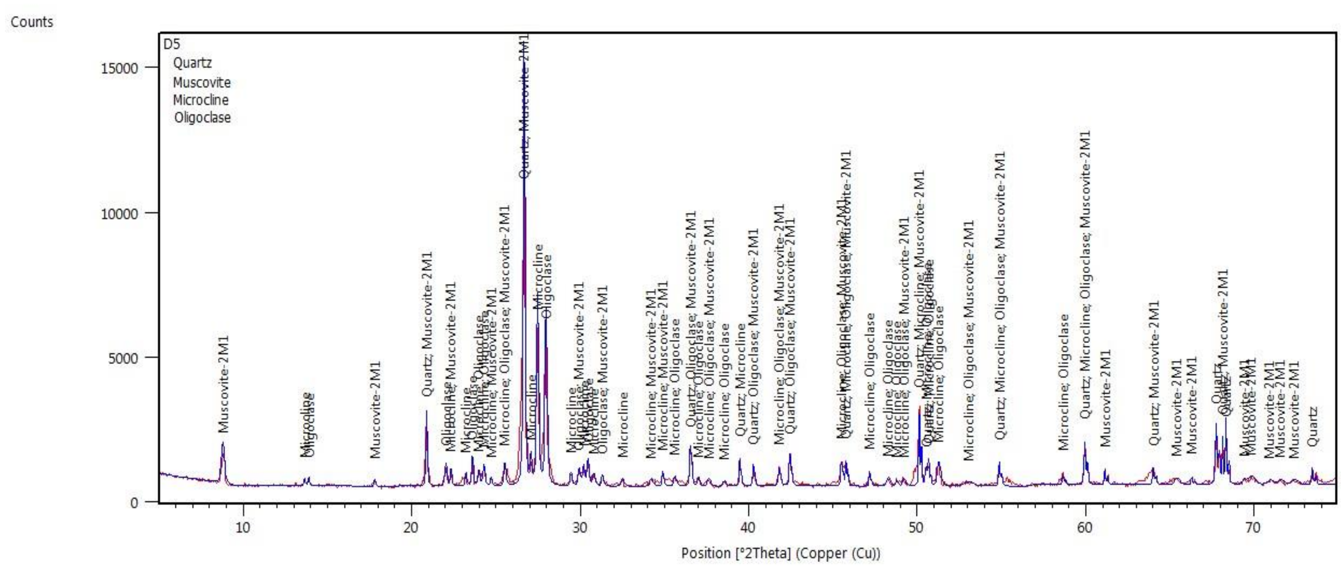

Figure: 10 XRD Spectra for Bera Rock

Quartz was the most abundant mineral found in the samples investigated. Quartz is the major ingredient of many igneous and metamorphic rocks. It is very tough and doesn't break easily. This may be the reason it was found to be the most predominant mineral in the rocks analysed. Quartz has numerous uses such as in the manufacture of glasses, used as oscillators in radios, watches, pressure gauges and in the study of optics. It is also essential in the computer industry, as main important silicon semiconductor (John and Steve, 2011). Orthoclase and microcline are polymorphs of potassium feldspars which are common raw materials for glasses and porcelain industries. Orthoclase has an attractive lusture used in jeweler (Berry *et al*., 2004, John and Steve, 2011). Phlogopite is a good electrical insulator and valued by electrical industry. It has great heat resistance that can withstand temperature up to 1000^{o}c (Berry *et al.*, 2004). It is also used in the manufacture of spark plugs. Biotite is a phylosilicate mineral within the mica group. It is used as a filler and extender in paints, as an additive to drilling muds, as an inert filler and mold-release agent in rubber products, asphalt shingles and rolled roofing. Albite is plagioclase feldspar with anorthic crystal system (Gualtieri, 2000). Albite are mined and used in manufacture of ceramics and gemstone (Berry et al., 2004). It is also a precursor of elemental sodium (Malaza and Zhao, 2009).

Table 2: Minerals Identified in Soil samples by X-Ray Diffraction in Song Local Government Area

Location	Minerals	Compound Name	Chemical Formula	Crystal System
Song (U1)	Quartz	Silicon dioxide	SiO_2	Hexagonal
	Albite	Sodium Aluminum Silicate	$NaAlSi_3O_8$	Anorthic
	Microcline	Potassium Aluminum Silicate	$KAlSi_3O_8$	Anorthic
	Muscovite	Potassium Aluminum Silicon Hydroxide	$KAl_2(AlSi_3O_{10})(OH)_2$	Monoclinic
Mbila(V1)	Albite	Sodium Aluminum Silicate	$NaAlSi_3O_8$	Anorthic
	Orthoclase	Potassium Aluminum Silicate	$KAlSi_3O_8$	Monoclinic
	Phlogopite	Potassium Magnesium Aluminum Silicon Hydroxide	$KMg_3(AlSi_3O_{10})(OH)_2$	,,
	Quartz	Silicon dioxide	SiO_2	Hexagonal
Muleng (W1)	Albite	Sodium Aluminum Silicate	$NaAlSi_3O_8$	Anorthic
	Muscovite	Potassium Aluminum Silicon Hydroxide	$KAl_2(AlSi_3O_{10})(OH)_2$	Monoclinic
	Microcline	Potassium Aluminum Silicate	$KAlSi_3O_8$	Anorthic
	Quartz	Silicon dioxide	SiO_2	Hexagonal
Mudungo (X1)	Albite	Sodium Aluminum Silicate	$NaAlSi_3O_8$	Anorthic
	Microcline	Potassium Aluminum Silicate	$KAlSi_3O_8$	Monoclinic
	Quartz	Silicon dioxide	SiO_2	Hexagonal
Domayo (Y1)	Albite	Sodium Aluminum Silicate	$NaAlSi_3O_8$	Anorthic
	Microcline	Potassium Aluminum Silicate	$KAlSi_3O_8$	Monoclinic
	Phlogopite	Potassium Magnesium Aluminum Silicon Hydroxide	$KMg_3(AlSi_3O_{10})(OH)_2$	Monoclinic
	Quartz	Silicon dioxide	SiO_2	Hexagonal
Sigire (Z1)	Albite	Sodium Aluminum Silicate	$NaAlSi_3O_8$	Anorthic
	Orthoclase	Potassium Aluminum Silicate	$KAlSi_3O_8$	Monoclinic
	Phlogopite	Potassium Magnesium Aluminum Silicon Hydroxide	$KMg_3(AlSi_3O_{10})(OH)_2$	Monoclinic
	Quartz	Silicon dioxide	SiO_2	Hexagonal
Murkumchi (A5)	Albite	Sodium Aluminum Silicate	$NaAlSi_3O_8$	Anorthic
	Biotite	Potassium Iron Aluminum Magnesium Silicate	$K(Mg,Fe)_3(AlSi_3O_{10})(F,OH)_2$	Monoclinic
	Microcline	Potassium Aluminum Silicate	$KAlSi_3O_8$	Monoclinic
	Quartz	Silicon dioxide	SiO_2	Hexagonal
Wuromod (B5)	Albite	Sodium Aluminum Silicate	$NaAlSi_3O_8$	Anorthic
	Microcline	Potassium Aluminum Silicate	$KAlSi_3O_8$	Anorthic
	Muscovite	Potassium Aluminum silicon Hydroxide	$KAl_2(AlSi_3O_{10})(FOH)_2$	Monoclinic
	Quartz	Silicon dioxide	SiO_2	Hexagonal
Wurotuge (C5)	Albite	Sodium Aluminum Silicate	$NaAlSi_3O_8$	Anorthic
	Muscovite	Potassium Aluminum silicon Hydroxide	$KAl_2(AlSi_3O_{10})(FOH)_2$	Monoclinic
	Orthoclase	Potassium Aluminum Silicate	$KAlSi_3O_8$	Monoclinic
	Quartz	Silicon dioxide	SiO_2	Hexagonal
Bera (D5)	Muscovite	Potassium Aluminum silicon Hydroxide	$KAl_2(AlSi_3O_{10})(FOH)_2$	Monoclinic
	Oligoclase	Sodium Aluminum Silicate	$(Na,Ca)Al_2Si_3O_8$	Anorthic
	Quartz	Silicon dioxide	SiO_2	Hexagonal

CONCLUSION

Nigeria is richly endowed with different types of solid minerals. For prospective exploration and mining, adequate knowledge of the Nation's reserves is essential for planning. This is because a mineral deposit is physical exhaustible and therefore irreplaceable. For any specific mineral commodity considered to be a reserve, our knowledge of the mineral deposit, the current mining status and metal sought should be available. The results presented in this study gives basic information on the status of the minerals identified. The economic potentials of the minerals and their applications are significant to many industries.

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CONFLICT OF INTEREST

No conflict of interest declared.

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Authors' contributions

MHM designs the topic and experimental methods, TK collected and processed the samples, while MC and NJA wrote and revised the manuscript.