FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 6 No. 1, March, 2022, pp 394 - 401
DOI: https://doi.org/10.33003/fjs-2022-0601-827

INVESTIGATION OF THE SOLID MINERAL DEPOSITS IN KANO STATE'S SCHIST BELT USING GEOCHEMICAL ANALYSIS

***[1]Shehu, J. S. and [2]Yelwa, N. A.**

[1]Department of Physics, Faculty of Science, Usmanu Danfodiyo University, Sokoto, Nigeria
[2]Department of Geology, Faculty of Science, Usmanu Danfodiyo University, Sokoto, Nigeria

*Corresponding authors' email: shehu.jamaluddeen@udusok.edu.ng Phone: +2348065358741

ABSTRACT

This paper uses geochemical analysis to investigate solid mineral deposits in Kano state's schist belt. A number of geophysical studies have recently focused on the area, with one of them estimating the causative body parameters through modeling of ground magnetic data collected in the study area; a follow-up study like this is thus required. Using an Agilent Microwave Plasma-Atomic Emission Spectrometer (MP-AES), eight rock samples from the study area were prepared for geochemical analysis. The study area was discovered to be rich in iron, chromium, aluminum, silicon, calcium, potassium, zinc, and manganese, with mean values of 157.10, 6.35, 274.71, 324.76, 27.83, 239.79, 25.49, and 160.20 ppm, respectively. Muscovite, Fuchsite, Biotite, Chlorite, and Quartz are schist minerals rich in these elements. Gold and silver were also discovered, although in small quantities, with mean values of 0.15 and 0.03 ppm, respectively. It is recommended that government and other stakeholders in the solid mineral industry should explore the study area in order to exploit these resources. It is also recommended that a radiometric study be conducted in the area to determine the presence of thorium and uranium, as well as the area's safety from radioactive hazards due to the high amount of potassium recorded.

Keywords: Geochemical Analysis, Kano State's Schist belt, MP-AES, Solid Minerals

INTRODUCTION

Because of the recent decline in the contribution of the oil and gas sector to the Nigerian economy's Gross Domestic Product (GDP), the Federal Government, led by President Muhammadu Buhari is determined to explore solid mineral sectors. In his statement reported in TheGuardian newspaper of 3rd April, 2016, the President said "We developed a mono-product economy and lost opportunities to diversify in the past. We have great potentials for Agriculture and Solid minerals. We are now determined to exploit them to the fullest. Addressing the past neglect of these two sectors will help to reduce unemployment and makes us a more productive country" (Adeoye, 2016). Today the mining sector accounts for 0.3% of national employment, 0.02% of exports and about USD 1.40 billion to the Nigerian GDP (Ministry of Mines and Steel Development, 2017). These statistics has a great potential for improvement if more works are done in discovering and exploring more mines.

The Schist belt part of Kano state is a promising area for many mineral resources. Located in the western part of the state and bounded within latitudes 11° 30' N to 12° 30' N and longitudes 7° 30' E to 8° 30' E, it sits in between Kazaure and Karau-Karau schist belts. It covers Shanono, Bagwai, Tsanyawa, Bichi and Kunchi local government areas of the state. Since 2018, specifically after the geoelectric study of Bagare *et al.*, (2018) this belt has begun to receive geophysical attention.

The aeromagnetic work of Shehu *et al.*, (2019a) revealed that the area is favourable for mineralization. The depth to the mineralized zones was later estimated in Shehu *et al.*, (2019b). In their ground magnetic study, Shehu *et al.*, (2021a) estimated the depth to the magnetic source bodies using euler deconvolution technique of the area bounded within longitudes 7° 58' 23'' E to 7° 59' 10'' E and latitudes 12° 6' 26'' N to 12° 7' 3'' N covering approximately 1.3 by 1 km^2. They obtained a range of 6.5 m to 39.8 m for contacts and 8.9 m to 51.3 m for dykes. Other parameters of the source bodies i.e. body dimensions and susceptibilities were estimated through 2-D inversion of the ground magnetic data in Shehu *et al.*, (2021b). The susceptibility values obtained from the inversion suggest that the area comprises of iron and chromium rich minerals as well as quartz. A confirmatory study to ascertain the actual minerals present in the study area is thus necessary. Geochemical analyses of rock samples such as one done by Amuda *et al.*, (2013) and Haruna *et al.*, (2017) in Wonaka and Karau-Karau schist belts respectively are a good confirmatory study to ascertain the minerals available in the study area.

Microwave Plasma Atomic Emission Spectroscopy (MP-AES) is a technique used in investigating the elemental composition. It uses the intensity of optical emission, by excited atoms, at a particular wavelength to determine the amount of element in a sample. The wavelength of the atomic spectral line in the emission spectrum gives the identity of the element while the intensity of the optical emission is directly related to the number of atoms of the element (Kilicgedik, 2012).

MP-AES offered a unique alternative to both atomic absorption spectrometry (AAS) and inductively coupled plasma atomic emission spectrometry (ICP-AES) techniques. Using nitrogen gas generated by nitrogen generator, the technique shows much promise for routine analytical application with several advantages such as smaller footprint, multi-element capability, relatively inexpensive, low maintenance cost, good detection power and speed (Balaram, 2020). MP-AES technique was successfully applied in many disciplines such as geochemistry (Balaram et al, 2014; Helmeczi et al, 2018), mineral exploration (Balaram et al 2013), environmental studies (Kamal et al., 2015; Sipahi and Uslu, 2016), agricultural studies (Akogwu et al., 2018) and so on. It proves robust enough to handle different types of sample matrices. Generally, the analytical capability of the MP-AES was found to be superior to that of AAS comparable to that of ICP-AES (Balaram, 2020).

This paper seeks to determine the solid minerals present around the schist belt area of Kano state by carrying out geochemical analysis on rock samples from the study area. The study area is bounded within longitudes 7.9764° E to

7.9858º E and latitudes 12.4663º N to 12.4995º N covering approximately 1.3 by 1 km^2

MATERIALS AND METHOD

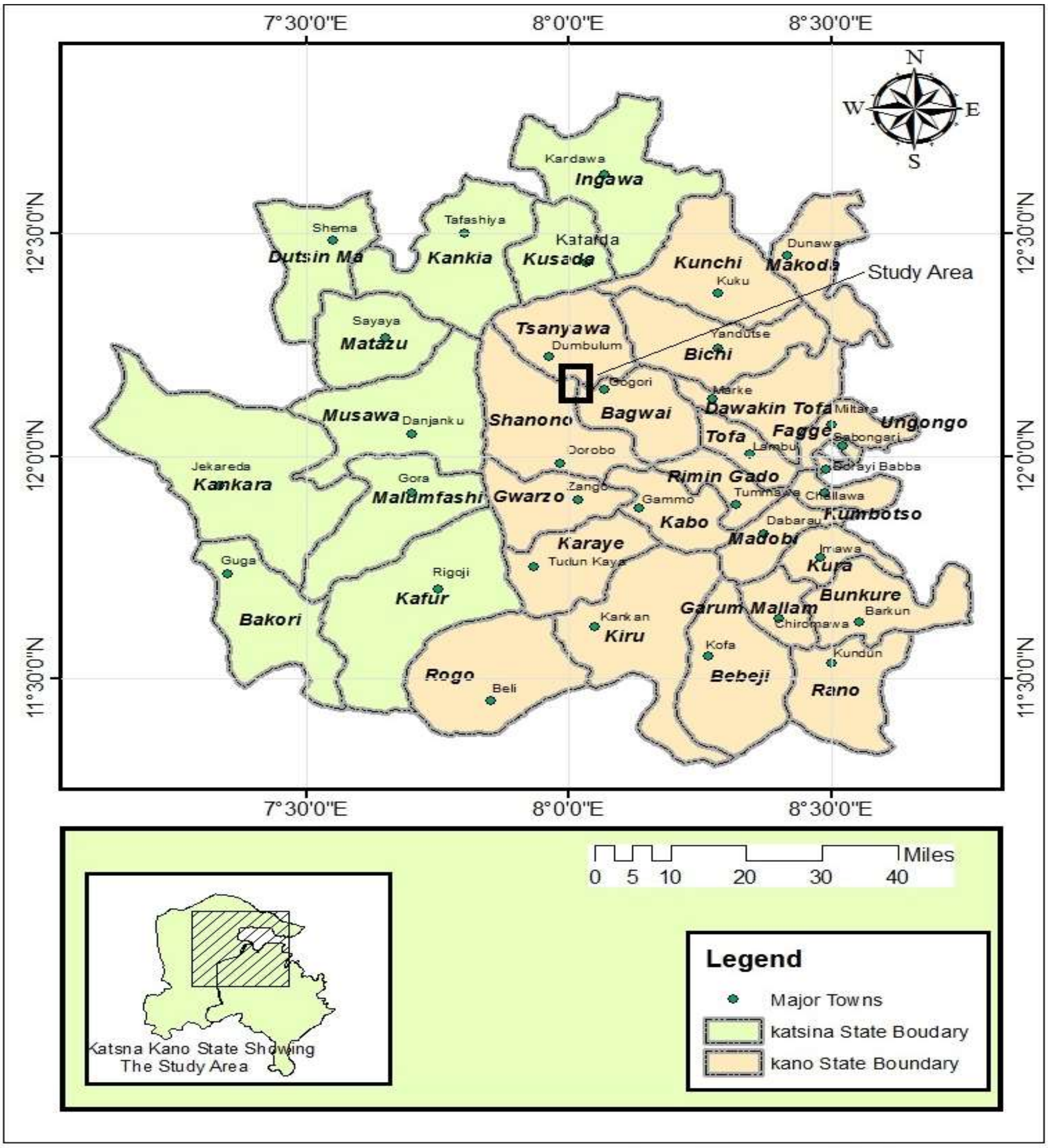
Materials

The materials used for this study are:

i. Agilent Microwave Plasma-Atomic Emission Spectrometer
ii. Hand held Global Positioning System (GPS) receiver
iii. Hydrochloric acid (HCl)
iv. Perchloric acid ($HClO_4$)
v. Nitric acid
vi. Hydrofluoric acid (HF)

Method

Eight rock samples were collected from the study area. Six out of the eight were from around the anomalous points delineated in Shehu *et al.*, (2021b); they were collected within depths of 2 to 3m. The remaining two samples were from outcrops found in other locations within the study area. The locations of the samples were recorded using the hand held GPS receiver.



Source:Cartography Lab Geography Department BUK

Figure 1. Geographic Map of the Study Area Shown in Black Square (Cartography Unit, Geography Dept., BUK, 2018).

Agilent Microwave Plasma-Atomic Emission Spectrometer was used to investigate the elemental composition of each rock sample.

After crushing each sample to powdered form, further preparations followed the standard provided by 'Agilent Technologies Inc.' (Kilicgedik, 2012). It involved a HNO_3–HCl–$HClO_4$–HF four acid digestion, with 0.4g of sample weight. The mixture was heated to near dryness and subsequently cooled. The digest was taken to a 100 mL final volume with 30% HCl solution, reflecting 250 times dilution. This four-acid digestion method yielded near total digestion of samples for the analysis.

RESULTS AND DISCUSSION

The sample names and location are shown in Table 1. Figures 1 to 8 show the bar chats of the elemental composition of the rock samples.

Table 1. Rock Sample Names and their Locations

Sample	Latitude in Degrees	Longitude in Degrees
I	12.47713	7.608855
II	12.47535	7.612986
III	12.47362	7.608746
IV	12.46758	7.607056
V	12.46809	7.610780
VI	12.47911	7.612361
VII	12.46925	7.614727
VIII	12.47634	7.605111

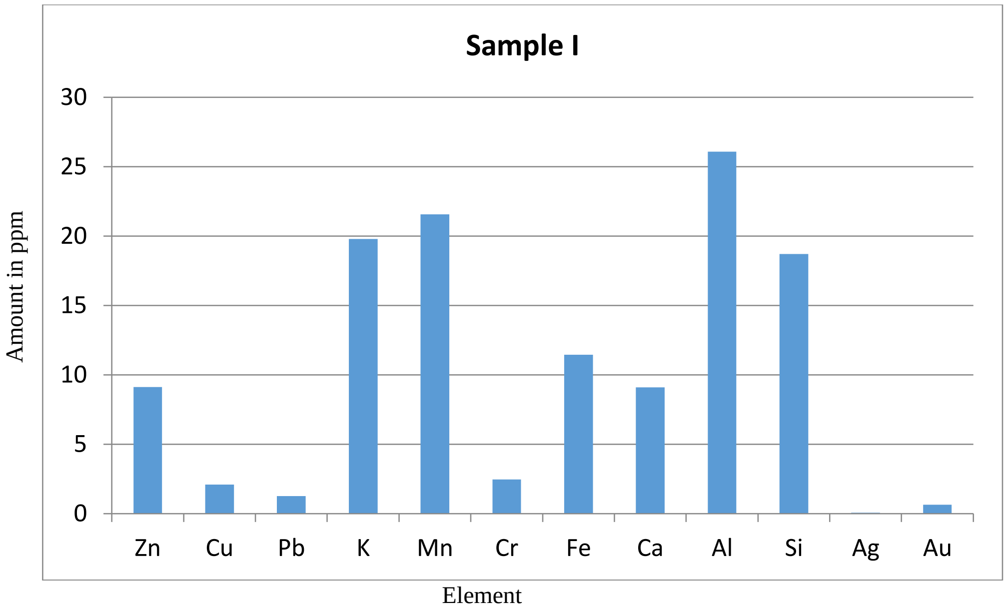


Figure 1. Elemental Composition of Sample I in PPM

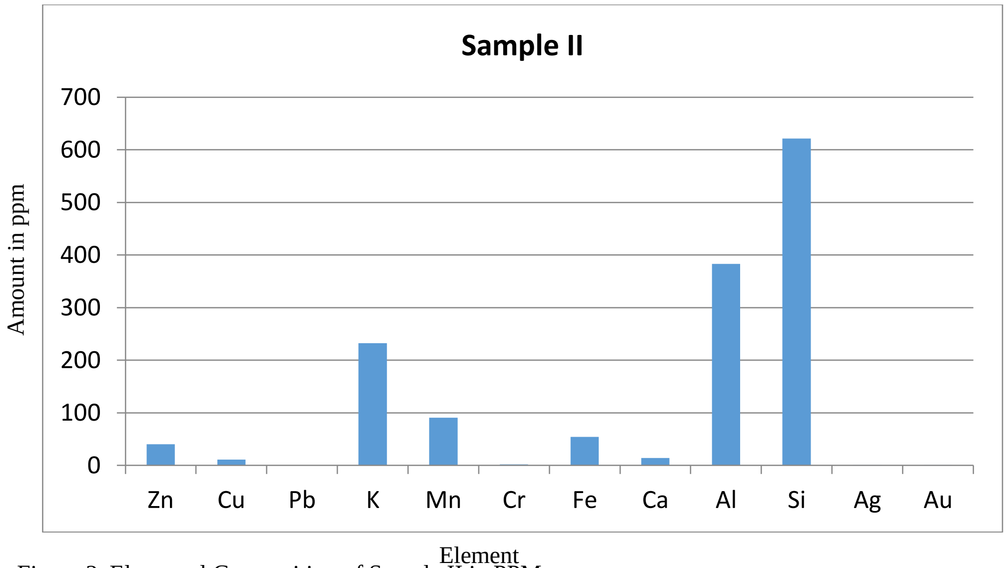


Figure 2. Elemental Composition of Sample II in PPM

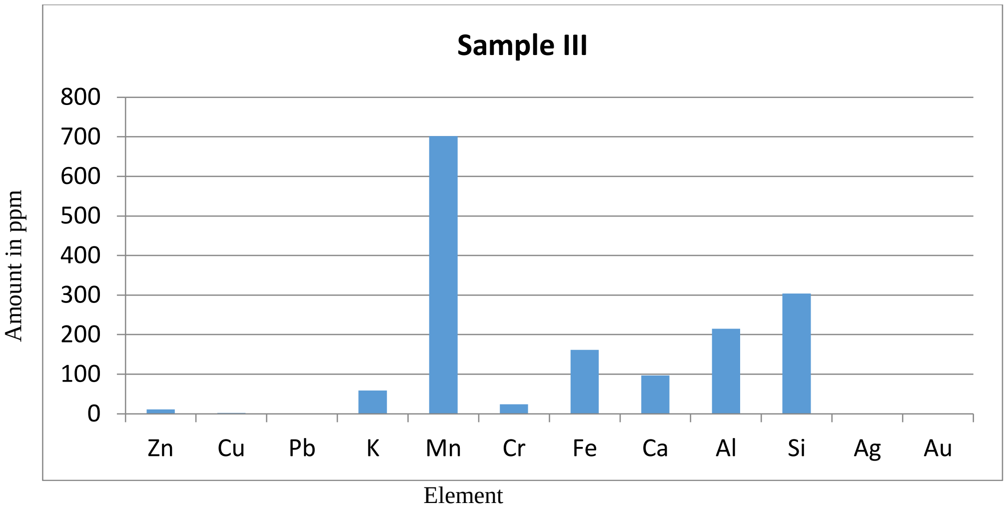


Figure 3. Elemental Composition of Sample III in PPM

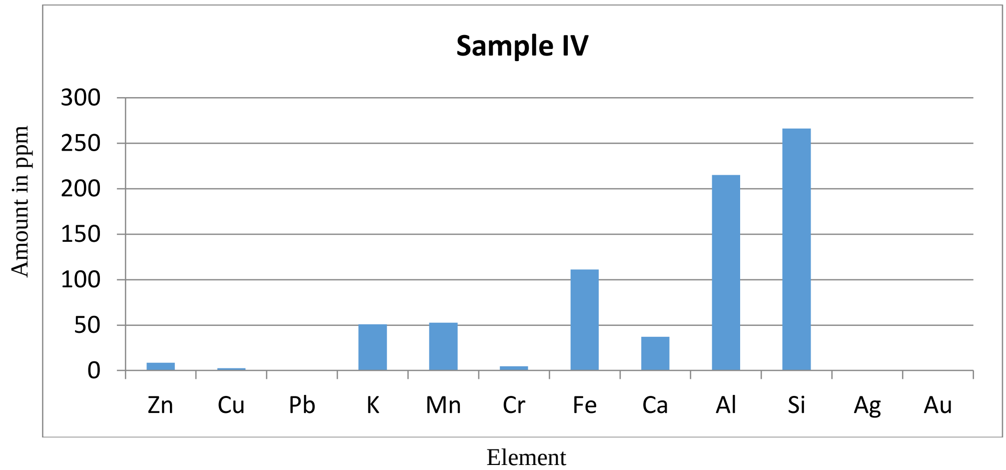


Figure 4. Elemental Composition of Sample IV in PPM

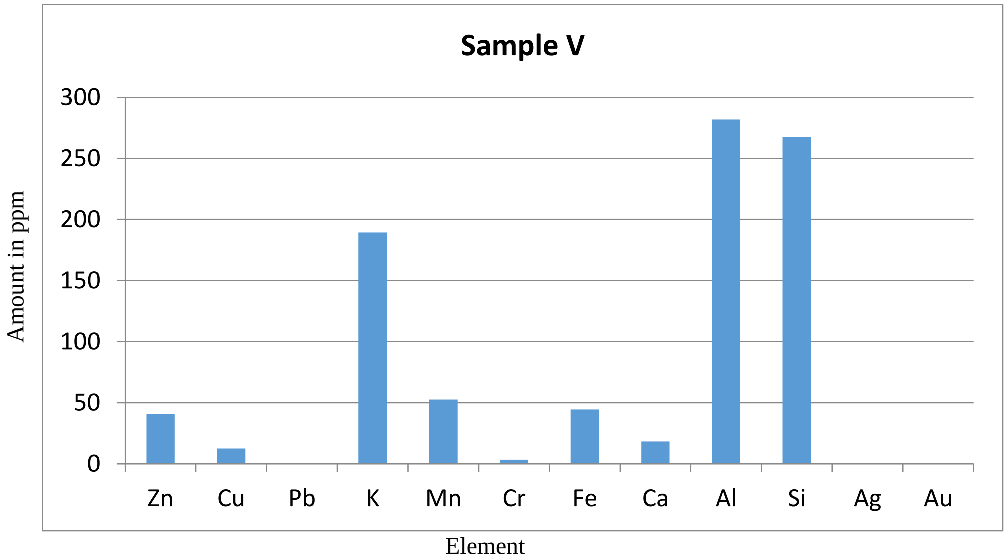


Figure 5. Elemental Composition of Sample V in PPM

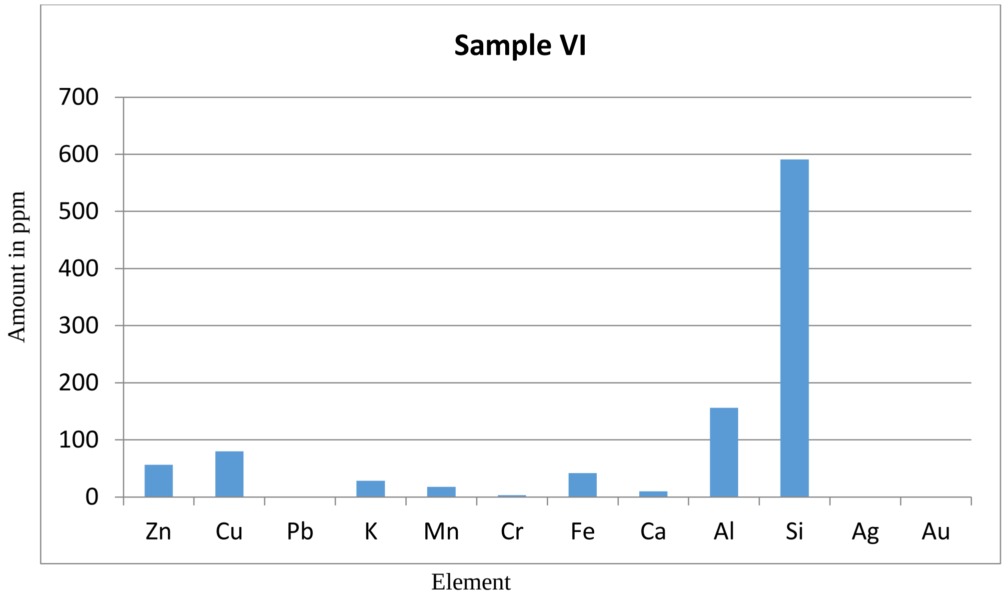


Figure 6. Elemental Composition of Sample VI in PPM

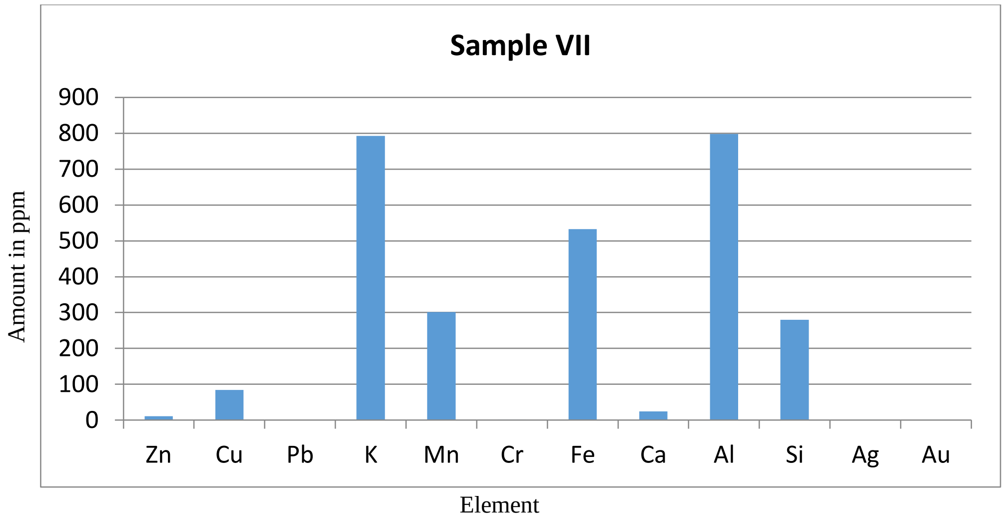


Figure 7. Elemental Composition of Sample VII in PPM

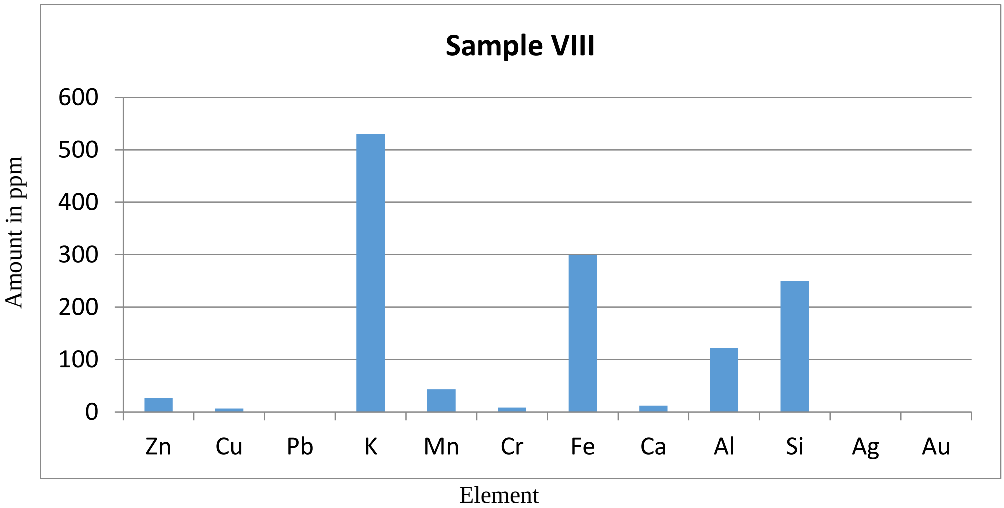


Figure 8. Elemental Composition of Sample VIII in PPM

Figure 1 shows the elemental composition in sample I. Al is the most abundant element in this sample with an amount of 26.08 ppm. Following Al are Mn, K and Si with respective values as 21.57 ppm, 19.78 ppm and 18.71 ppm. The quantity

of Au and Ag in this sample is 0.64 ppm and 0.06 ppm respectively. The amount of Pb in this sample is 1.25 ppm.
The elemental composition of sample II is shown in Figure 2 with Si being the highest with an amount of 621.32 ppm. Al and K have 383.3 ppm and 232.47 ppm respectively as their amount. The quantity of Au and Ag in this sample is 0.18 ppm and 0.02 ppm respectively.
In sample III (Figure 3), Mn, Si and Al are the three highest elements in quantity. Their values are 7.1.52 ppm, 303.89 ppm and 216.25 ppm respectively. Au has an amount of 0.11 ppm while Zn and Cu have an amount of 11.08 and 2.43 ppm respectively.
Si, Al and Fe are the three most abundant elements in sample IV shown in Figure 4 with values as 265.98 ppm, 214.99 ppm and 111.07 ppm. K and Mn are almost of equal quantity with values of 51.04 ppm and 52.74 ppm respectively. Au and Ag have an amount of 0.08 and 0.01 ppm respectively.
Figure 5 shows the elemental composition of sample V. the amount of Al, Si and K are 281.99 ppm, 267.43 ppm and 189.31 ppm respectively. Fe, Zn and Mn have an amount of 44.36 ppm, 40.78 and 52.6 ppm respectively. Au and Ag have their values as 0.06 ppm and 0.03 ppm respectively.
In sample VI (Figure 6), Si is evidently most abundant with a value of 590.94 ppm. Al, Cu, Zn and Fe have an amount of 156.32 ppm, 79.71 ppm, 56.33 ppm and 41.89 ppm respectively.
The three most abundant elements in sample VII (Figure 7) are Al, K and Fe. Their values are 797.59 ppm, 792.9 ppm and 532.92 ppm respectively. Mn, Si and Cu have an amount of 301.41 ppm, 280.26 ppm and 84.37 ppm respectively
Figure 8 shows the elemental composition of sample VIII. K is the highest in this sample followed by Fe and followed by Si. Their values are 529.45 ppm, 299.16 ppm and 249.55 ppm respectively. Ca, Cr and Cu are relatively low in quantity with their values as 12.09 ppm, 8.25 ppm and 6.39 ppm respectively
Table 2 shows the summary statistics of the geochemical data in part per million (ppm).

Table 2: Summary Statistics of Geochemical Data

Element	Minimum (ppm)	Maximum (ppm)	Mean (ppm)	SD (ppm)
Zn	8.55	56.33	25.49	18.40
Cu	2.08	84.37	25.21	35.33
Pb	0.00	1.25	0.16	0.44
K	19.78	792.90	237.79	281.27
Mn	17.60	701.52	160.20	237.29
Cr	2.25	24.31	6.35	7.52
Fe	11.44	532.92	157.10	177.82
Ca	9.10	97.18	27.83	29.53
Al	26.08	797.59	274.71	236.48
Si	18.71	621.32	324.76	195.40
Ag	0.00	0.09	0.03	0.03
Au	0.04	0.64	0.15	0.20

All the samples comprise of minerals rich in Si, Al, Fe, Ca, Mn, K, Zn and Cr. Muscovite {$KAl_2(AlSi_3O_{10})(OH)_2$}, Fuchsite {$KCr_2(AlSi_3O_{10})(OH)_2$}, Biotite {$K(Mg,Fe)_3(AlSi_3O_{10})(F,OH)_2$}, Chlorite {$(X,Y)_{4-6}(Si,Al)_4O_{10}(OH,O)_8$} ('X' and 'Y' could be Fe^{+2}, Fe^{+3}, Mg^{+2}, Mn^{+2}, Ni^{+2}, Zn^{+2}, Al^{+3}, Li^{+1} or Ti^{+4}) and quartz {SiO_2} are schist minerals comprising these elements (King, 2019a,b,c,d,e). The study area is generally free of lead contamination except in sample I, with 1.25 ppm which is also below the range of normal occurrence (15 to 40 ppm) in the soil (www.ag.umass.edu, 2019). Ag and Au are very small in the study area with mean values of 0.034 ppm and 0.15 ppm respectively. This is usually the case with Au; for example Elliott and Wells (1968), Nude *et al.,* (2012), Arhin *et al.,* (2015), Anand *et al*., (2018) and others reported a mean value <0.5 ppm for Au. This explains why gold is generally scarce and always takes several strenuous processes to explore.

CONCLUSION

In this study, it was found that the study area comprises of a conglomerate of minerals rich in iron, chromium, aluminum, silicon, calcium, potassium, zinc and manganese with mean values of 157.10, 6.35, 274.71, 324.76, 27.83, 239.79, 25.49 and 160.20 ppm respectively. Schist minerals rich in these elements are Muscovite, Fuchsite, Biotite, Chlorite and Quartz. Although in small quantity, gold and silver were also found to be in the study area with mean values of 0.15 and 0.03 ppm.
These minerals are economically significant. Quartz for example, is one of the most useful natural materials. Its usefulness is related to its physical and chemical properties. It has a hardness of seven on the Mohrs scale which makes it durable. It has electrical and heat resistance that make it valuable in electronic products. Its luster colour makes it useful as gemstone and also in the making of glass (King, 2019a). Biotite is used as a filler and extender in paints, as well as an additive in rubber products. When struck by sunlight, the tiny flakes of biotite turn a bronze colour, leading the miner to believe he has discovered gold until it is poked with a pin. This is why it is known as "fool's gold" in geology (King, 2019b).
Muscovite is an excellent insulator making it suitable for manufacturing of specialized parts of electrical equipment. Furthermore, the pearlescent luster of muscovite makes it an important ingredient that adds glitter to paints, ceramic glazes and cosmetics. Fuchsite is a green variety of Muscovite with trivalent chromium in the place of aluminum within the mineral. Chromium is the source of Fuchsite's green colour

(King, 2019 c and d).Chlorite usually intermixes with other minerals and the cost of separation would be high. As a result, Chlorite is not mined and processed for any specific use (King, 2019e).

Gold is the most used mineral mined from the earth; its uses are found in electronics and computer devices, medicine, aerospace devices, jewelry, medals, coins etc. This is because it conducts electricity, does not tarnish, very easy to work, can be drawn into wire, can be hammered into thin sheets, alloys with many other metals an cast into highly detailed shapes, has a wonderful colour and brilliant luster. This explains why gold has found a high place in the human minds throughout world history (King, 2019f). Silver, just like gold, has many uses ranging from jewelry to industrial uses. It is however more abundant than gold (Ferre, 2019).

The recommendations for the government and other mining industry stakeholders, as well as for future research, are as follows:

i. Government and other stakeholders in the solid mineral industry should explore the areas mapped out in this study in order to explore it solid mineral potential.
ii. Since potassium can be radioactive and because of its quantity (mean value of 237.79 ppm) found in the study area, it is recommended to carry out a radiometric study in the area for possible presence of thorium and uranium and to ascertain the safety of the area from radioactive hazard.
iii. Finally, it is suggested that systematic detailed integrated geophysical studies should be carried out in the remaining parts of mineralized zones of the Schist belt of Kano state.

REFERENCES

Adeoye, K (2016). Solid minerals in Nigeria: An overview (1). *TheGuardian.* https://guardian.ng/energy/solid-minerals-in-nigeria-an-overview-1/ retrieved on 7/10/2018

Akogwu, R.D., Aguoru, C.U., Ikpa, F., Ogbonna, I & Olasan, J.O (2018). Relevance of industrial wastes from Jatrophacurcas L. seed in agricultural biotechnology, Int. J. Environ. Agricul. Biotechnol. 3, 1547-1551.

Amuda, A.K, Danbatta, U.A, and Najime, T (2013). Geology and Gold Mineralization around Kutcheri, northwestern Nigeria. *IOSR Journal of Applied Geology and Geophysics.* e-ISSN: 2321-0990, p-ISSN: 2321-0982, Vol. 1(6) pp. 18 - 24.

Anand, R.R., Hough, R.M., Salama, W., Apandiar, M.F., Butt, C.R.M., Gonzalez-Alvarez, I. and Metelka, V. (2018). Gold and pathfinder element in ferricrete gold deposits of the Yilgran Craton of Western Australia: A review with new concepts, *Ore Geology Reviews*, doi: https://doi.org/10.1016.joregeorev.2018.11.003

Arhin, E., Boadi, S. and Hall, M.C. (2015). Identifying pathfinder elements from termite mound samples for gold exploration in regolith complex terrain of the Lawara belt, NW Ghana, *African Earth Sciences,* doi: http://dx.doi.org/10.1016/j.jafrearsci.2015.05.022

Bagare, A.A, Saleh, M., Aku, A.O. andAbdullahi, Y.M. (2018). 2D Electrical Study to Delineate Subsurface Structures and Potential mineral zones at Alajawa Artisanal Mining Site, Kano State, Nigeria. *Journal of the Nigerian Geophysical Society,* 1(1): 24 - 32. https://www.niggs.org/jngs/2018/1_1/bagare_024032

Balaram, V. (2020). Microwave Plasma Atomic Emission Spectrometry (MP-AES) and its Applications – A Critical Review, *Microchemical Journal*. doi: https://doi.org/10.1016/j.microc. 2020.105483

Balaram, V., Dharmendra, V., Roy, P., Taylor, C., Kar, P., Raju, A.K & Krishnaiah, A. (2013). Determination of precious metals in rocks and ores by microwave plasma-atomic emission spectrometry (MP-AES) for geochemical prospecting, Current Science 104, 1207-1215.

Balaram, V., Dharmendra, V.,Roy, P., Taylor, C., Kamala, C.T, Satyanarayanan, M., Kar, P., Subramanyam, K.S.V., Raju, A.K & Krishnaiah, A. (2014). Analysis of geochemical samples by microwave plasma-AES, At. Spectrosc. 35, 65-78.

Elliot, J.E. and Wells, J.D. (1968). Anomalous Concentrations of Gold, Silver, and Other Metals in the Mill Canyon Area Cortez Quadrangle, Eureka and Lander Countries, Nevada. *Geological Survey Circular 606.* Unites States Department of Interior, Washington DC.

Ferre, E.C. (2019). The many uses of silver. www.geology.com/articles/uses-of-silver/ retrieved on 17/08/2019

Haruna, A.I, Umar U.S, Rilwan, A., Mohammed A.D, Nabage, N.A. and Aliyu, M. (2017). Gold Preliminary Exploration arounf Karau-Karau Schist Belt, NW-Nigeria. *International Journal of Geology and Earth Sciences,* 3(4).

Helmeczi, W., Helmeczi, E., Baker, L.A, Wang, Y., Brindle, I.D (2018). Development of a general acid method for the digestion of gold ore samples together with a comparison of extraction solvents for gold and determination by microwave-induced plasma-atomic emission spectrometry (MIP-AES), J. Anal. At. Spectrom. 33, 1336–1344.

Kamala, C.T., Balaram, V., Dharmendra, V., Roy, P., Satyanarayanan, M., Subramanyam, K.S.V (2015). Application of microwave plasma atomic emission spectrometry (MP-AES) for environmental monitoring of industrially contaminated sites in Hyderabad city,Environ. Monit, Assess. 186, 7097–7113.

Kilicgedic, E (2012). Introducing the Revolutionary New Microwave Plasma Emission Spectrometer – It Runs on Air! www.agilent.com/en/product/atomic-spectroscopy/microwave-plasma-atomic-emission-spectroscopy-mp-aes visited on 27/06/2020.

King, H.M (2019a). Quartz. www.geology.com/mineral/ quartz.shtml retrieved on 17/08/2019

King, H.M (2019b). Biotite. www.geology.com/minerals/ biotite.shtml retrieved on 17/08/2019

King, H.M (2019c). Muscovite. www.geology.com/mineral/ muscovite.shtml retrieved on 17/08/2019

King, H.M (2019d). Fuchsite. www.geology.com/minerals/ fuchsite.shtml retrieved on 17/08/2019

King, H.M (2019e). Chlorite. www.geology.com/minerals/ chlorite.shtml retrieved on 17/08/2019

King, H.M (2019f). The many uses of gold. www.geology.com/mineral/gold/uses-of-gold.shtml retrieved on17/08/2019

Ministry of Mines and Steel Development (2017). Nigerian's mining and Metal Sector Investment Promotion Brochure

Nude, P.M., Asigri, J.M., Yidana, S.M., Arhin, E., Foli, G and Kutu, J.M. (2012). Identifying Pathfinder Elements for Gold in Multi-Element Soil Geochemical Data from the Wa-Lawra Belt, Northwest Ghana:: A Multivariate Statistical Approach. *International Journal of Geosciences*, Vol. 3 pp. 62 – 70. Doi: 10.4236/ijg.2012.31008

Shehu, S.J., Aku, M.O., Saleh, M., Bunawa A.A and Sharafa, S.B. (2019a). A reconnaissance study to delineate the potential mineral zones around the schist belt areas of Kano state, Nigeria using airborne magnetic data. *Journal of Geology and Mining Research.* Vol. 11(2), pp.14 – 21. Doi:10.5897/GMR2018.0307

Shehu, S.J., Aku, M.O., Saleh, M., Bunawa, A.A and Ali, M.H. (2019b). Estimation of Depth to magnetic Source Body Using Source Parameter Imaging around the Schist Belt Areas of Kano, North Western Nigeria. *Journal of Nigerian Association of Mathematical Physics*, Vol. 51 (May 2019 Issue), pp233 – 236

Shehu, S.J., Aku, M.O., Saleh, M., Bunawa, A.A Lawan, M and Sani, F (2021a) The use of euler deconvolution technique in the estimation of depth to magnetic source bodies around the schist belt parts of kano State, Nigera. Jourdan Journal of Physics, volume 14, Number 1, pp 19-23. Doi: https://doi.org/10.47011/14.1.2

Shehu, S.J., Aku, M.O., Saleh, M., Bunawa, A.A., Abdullahi, Y.M and Mohammed, A (2021b) 2D-Inversion of Ground Magnetic Data Acquired Around the Schist Belt Areas of Kano State, Nigeria For Estimation Of Causative Body Parameters. FUW Trends in Science & Technology Journal, www.ftstjournal.com e-ISSN: 24085162; p-ISSN: 20485170; December, 2021: Vol. 6 No. 3 pp. 842 – 848

Sipahi, F & Uslu, S (2016). Investigation of the quality and physical-geochemical characteristics of the drinking water in Gümüşhane (Turkey) city central, Arab. J. Geosci. 9, 1-14.
www.ag.umass.edu/soil-plant-nutrient-testing-laboratory/fact-sheets/soil-lead-testing-interpretation-recommendations visited on 15/08/2019