

# Geochemical Investigation of Gold and Chalcophile Minerals of Rawayau Area Katsina State, Nigeria.

Aliyu Ibrahim Kankara<sup>1</sup>, \*Terlumun Adagba<sup>2</sup>

<sup>1</sup>Department of Geology,  
Federal University Dutsin-Ma,  
Nigeria

<sup>2</sup>Department of Civil Engineering,  
Federal University Dutsin-Ma,  
Nigeria.

Email: adagbat@gmail.com

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## Abstract

*This present study investigated the Gold and Chalcophile mineralisation potentials of the Rawayau area in Northwestern Nigeria. The aim of the investigation is to delineate the likely Gold and Chalcophile mineralisation occurrences in the study area so as to aid further exploration studies that will identify Gold rich targets worth investing resources for detail exploration project before mining. To achieve this, 17 samples (7 rock samples and 10 sediments) were collected and subjected to laboratory analysis at the National Geologic Survey Agency (NGSA) in Kaduna. The geochemical study showed that the Au concentration ranged from below detection level (bdl) to 0.09ppm in the rock samples, while ranging from 0.013ppm to 0.137ppm in the sediments. Ag concentration ranged from 0.37ppm to 0.97ppm with in the rock samples, while ranging from 0.088ppm to 0.229ppm in the sediments, thus showing a higher concentration in both rock and sediments than Au. Significant positive relationship was observed between Ni, Cr, Cu, Mn, Fe, Zn and Co from the correlation analysis. It also revealed a subsurface increment of Gold and Chalcophile concentration of Nickel, Copper and Zinc with higher concentration of Nickel, Copper, Zinc, Manganese, Chromium and Lead in comparison to Gold and Silver. The study concludes that the Rawayau area holds much prospects for Gold and other minerals. It is suggested that further exploratory studies be carried out so as to pave way for the commencement of mining activities in the study area".*

**Keywords:** Geochemical investigation, chalcophile minerals, gold mineralization, threshold, Rawayau.

## INTRODUCTION

A major source of raw materials which drive industrialization globally is mineral resources. Mineral resources such as gold, iron ores, tins, marbles, limestone are essential in the manufacturing, cosmetic and construction industries to mention a few. (Adebayo and Obasaju 2021). Gold is an important mineral resource found in the subsurface, and it's mineralisation is controlled by a series of geological processes, structures and hydrothermal rock formation alterations (Sani *et al.*, 2019). Almost 90% of Nigeria's entire gold production comes from alluvial deposits gotten from primary gold mineralization in basement rocks. These basement rocks of several known goldfields are mostly distributed within the western part of Nigeria

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\*Author for Correspondence

(Andongma *et al.*, 2020). Other minerals having high economic value also occur in most areas of North-western Nigeria (Kankara *et al.*, 2021).

The integrated approach of geological and geochemical studies in modern day exploration for minerals cannot be overemphasized. Geochemical studies using soil and rocks as sampling media help in the delineation of likely areas of mineralization for further exploration studies. In Nigeria, several studies on Gold mineralization and the host rocks have been carried out, notably the Anka Schist Belt (Sani *et al.*, 2019), Maru Schist (Oke *et al.*, 2014; Abiola *et al.*, 2017), Zuru Schist (Ahmed *et al.*, 2019; Fagbohun *et al.*, 2021), Zungeru Schist (Aliyu *et al.*, 2021; Mohammed *et al.*, 2021), Wonaka Schist (Amuda *et al.*, 2013; Germa and Andongma, 2020), Ilesha Schist (Olajide-Kayode *et al.*, 2020), Malumfashi Schist (Andongma *et al.*, 2020; Andongma *et al.*, 2021). They reported on the presence of gold mineralization in alluvial (stream sediments) and eluvial placers (soils) and primary veins (quartz veins) from several parts of supracrustal (schist) belts in the northwest and southwest of Nigeria. None of the Nigerian schists exists outside Longitude 8°E, thus they are localised mostly to the western part of country. (Balogun, 2019).

Areas of these gold occurrences that are close to Rawayau area are like those that lie about 76km SW of the Shanono and Bagwai gold areas, which is also at the SW of Kafur to Tandama/Rafin Gora gold areas of Danja, the southwestern part of Kazaure schist belt and NE of Kankia gold area.

The investigated rocks are characterized by intense alterations. More than two-hundred (200) gold-bearing quartz veins are recorded which run parallel to these alteration zones (Kankara, 2018). These veins which occur in association with metamorphosed rocks, range in composition from quartz ± gold to those of mafic minerals. (Nforba *et al.*, 2020).

The soil and stream sampling geochemical investigation technique has been used by several researchers to study gold mineralisation in several gold fields in Nigeria. (Omanayin and Ogunbajo, 2016; Abiola *et al.*, 2017; Haruna *et al.*, 2017; Ahmed *et al.*, 2019), however, there are no documented reports on the study of gold in the Rawayau area. This study therefore employs the use of the soil and stream sediments sampling geochemical technique to investigate the gold and chalcophile minerals potential of the Rawayau area. It is believed that this preliminary investigation will provide the information needed for further exploration studies to identify gold rich targets that are worth investing resources for a detailed exploration project before mining. (Haruna *et al.*, 2017)

### **Study Area**

Rawayau found in Kurfi Local Government Area of Katsina State is bounded approximately by Latitudes 7° 35' 00" to 7° 36' 50" and Longitudes 12° 35' 00" to 12° 36' 50". Located about 45km from the state capital, off Katsina Charanchi road. It is characteristically made up of veins and quartzofeldspathic rocks, mica schist which forms a monotonous expanse with consistent foliation trends. The schist is a fine-grained quartz-biotite rock, in places containing sillimanite, cordierite or garnet. Thin beds of calc-silicate rocks are widely distributed as injections into the schist, now mostly seen as distinctive weathered 'bony' residuum or floats. The study area has an approximate extent of 3.2 km<sup>2</sup> and within Sheet 34, Katsina SW. The eastern part of the area is accessible through the Charanchi-Rawayau road and the western parts are accessible along the Rawayau, Kurfi road. Although there are many hills in the study area due to high relief, the availability of foot-paths and cattle rearing paths within the license made it quite accessible.

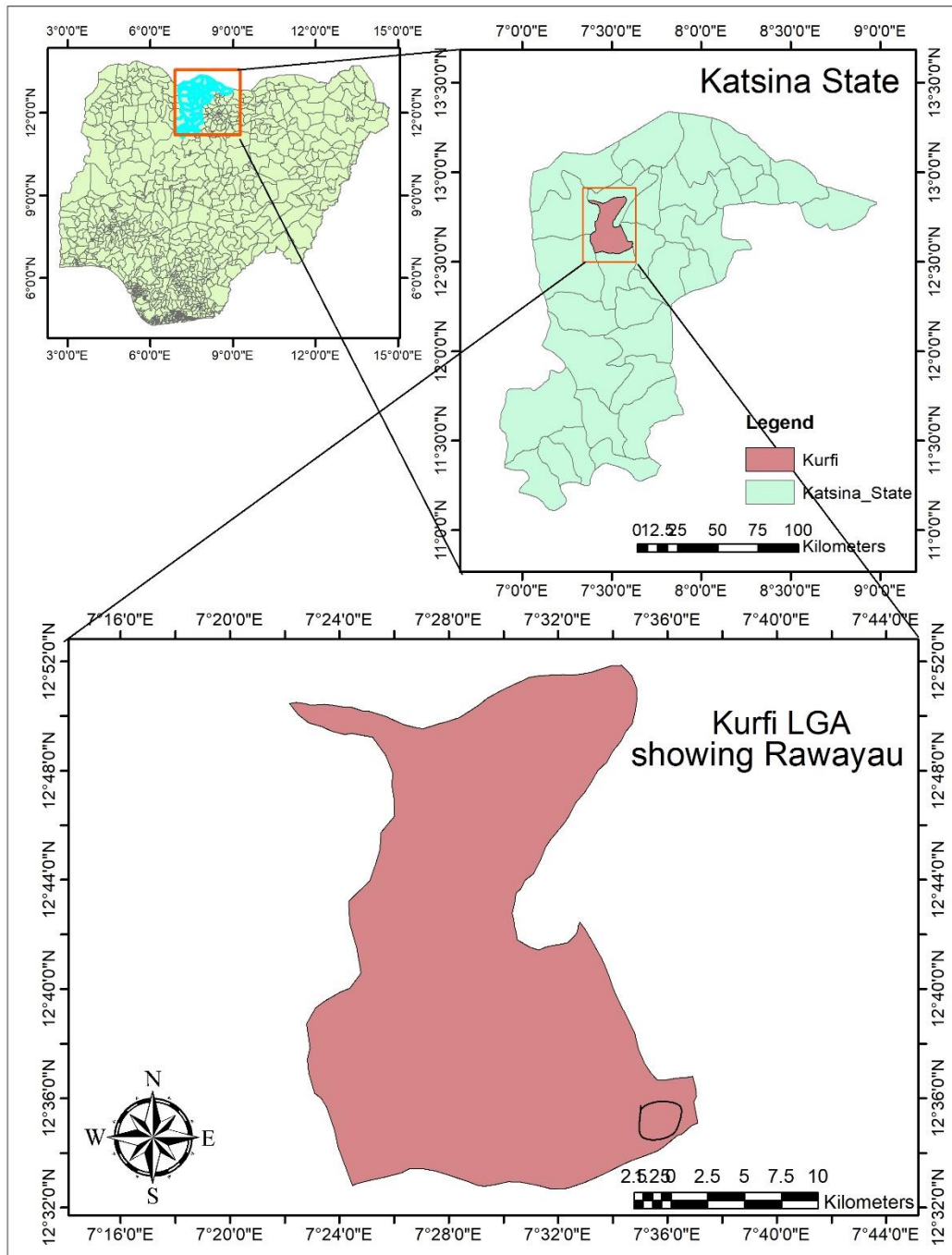
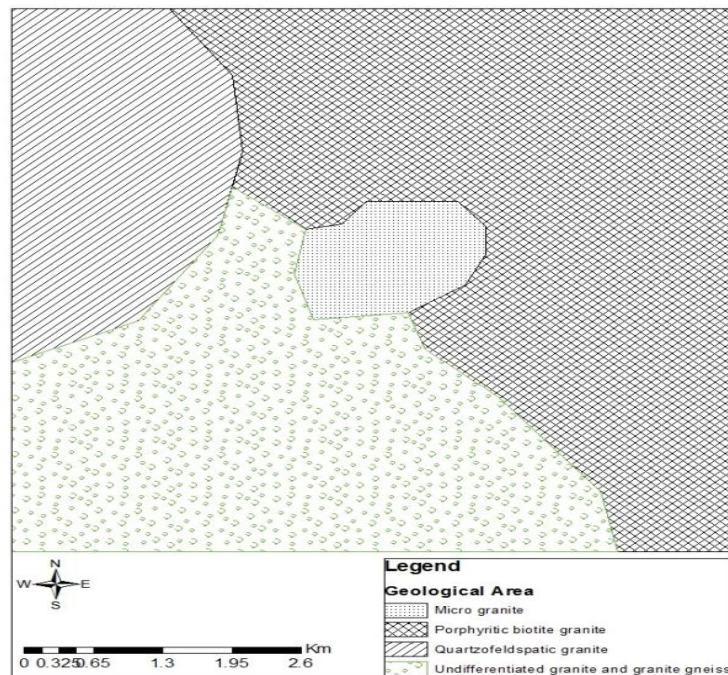


Fig. 1: Map showing the location of Rawayau environs



Geological Map of Rawayau Area

Fig 2: Geological map of Rawayau environ

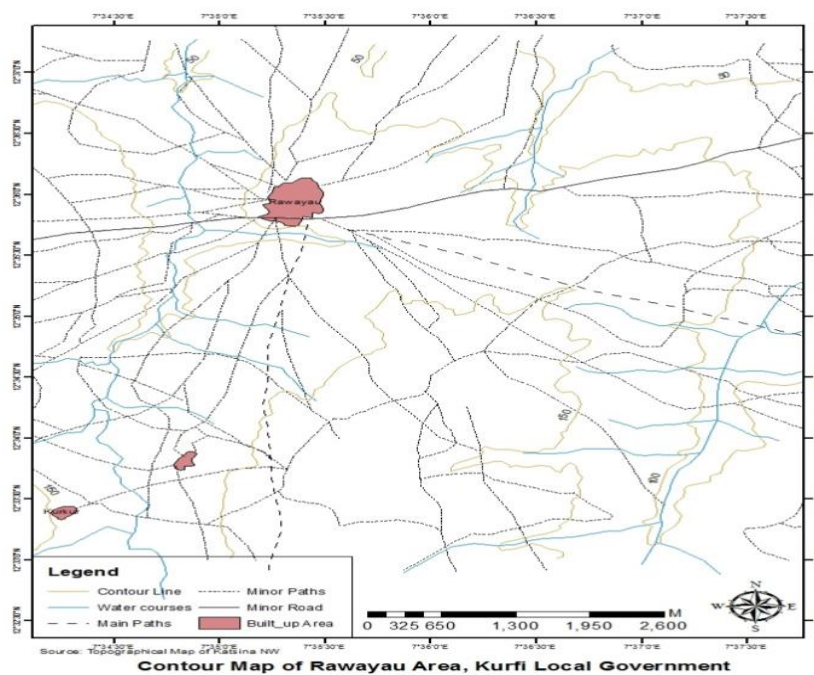


Fig 3: Contour map of the study area

### Sampling

The first phase of the pre-exploration involved reconnaissance survey, collection of raw and surface samples for laboratory analysis of gold and other sulfide minerals was conducted. Subsequently, geochemical sampling of rocks, soil and stream sediments was undertaken over the entire area, considering the lithological units and alterations.

Samples were collected for crushing, panning and calabashing, as can be seen in Plate 6, thereby analysing the heavier materials through the process of gravimetry. Rocks samples collected at several locations during geological mapping include pegmatite veins, quartz veins, quartzite and schist with the coordinates recorded. Descriptions of the rocks were done and information on the texture, mineralogy and colour were recorded, the deformation structures on the rocks were observed and their orientations recorded.

The soil sampling was conducted with a sample spacing of 100 meter and 100 meter line spacing using pits of 1m by 1m. Some areas were defined as target areas where geochemical soil samples were collected in a well gridded pattern based on the presence of certain lithologies, alteration and structures peculiar to gold mineralization. Alluvial (stream) samples were collected and panned. Seventeen (17) samples were collected for laboratory analysis.

### **Laboratory Analysis**

The preparation of samples for geochemical analysis involved processes such as drying, crushing, grinding, milling and sieving of the samples to the required particle size and desired texture. Elements analysed include Au, Ag, Ni, Na, Co, Cr, Cu, Zn, Mn, Pb, Fe, Ca, and K. This was carried out at the Nigerian Geological Survey Agency (NGSA) Kaduna.

### **Statistical Analysis**

To carry out statistical analysis, the Microsoft Excel 2016 package was used. Standard statistical procedures used in this study include descriptive statistical parameters such as Mean, Median, Standard Deviation, Median Absolute Deviation. The Pearson rank correlation was employed to determine the strength and relationship between various elements analysed using the geochemical data obtained. The Pearson correlation coefficient measures the strength of any linear relationship between two variables. (Usman *et al.*, 2020).

### **Geochemical threshold values**

According to Salomao *et al.*, (2021), there are three main methods adopted by researchers in estimating geochemical threshold values: the Median + 2 \* Median Absolute Deviation (Med. + 2 \* MAD), the Tukey's Inner Fence (TIF) and the Percentile Based approaches of which the Median + 2 \* Median Absolute Deviation is mostly used. The use of the mean in estimating threshold values is considered outdated, also, the mean is significantly affected by anomalous values. (Fagbohun *et al.*, 2021; Salomao *et al.*, 2021).

The Median + 2 \* Median Absolute Deviation method was used in this study. The method is as given in equations (1) and (2) below according to Fagbohun *et al.*, (2021).

$$M_{AD} = med. |x_i - med(x_i)| \quad (1)$$

$$T = med + 2M_{AD} \quad (2)$$

Where:

$M_{AD}$  is the Median Absolute Deviation, med is the median,  $x_i$  is the element concentration and T is the threshold value.

### **Geological Setting of the Mapped Rocks**

Structurally, both ductile (foliation, folding) and brittle structures (joints, faults) were observed in the study area. The dark brown mica schist has remarkable dipping foliation that is highly inclined. The Phanerozoic rocks on the other hand are rocks of Cambrian to Recent in age. These have been referred to as the Younger granites and their associated volcanic rocks by various authors (Prinkey, 2001). The younger metasediments commonly referred to as the schist consist of schistose rocks of Achaean to Late Proterozoic. They occur rampantly in almost all the areas.

### **Mineralization**

The Rawayau area is part of the Neo-proterozoic to early phanerozoic terrain of northwestern Nigeria (Kankara, 2014). The Neo-proterozoic rocks are represented by highly decomposed schist constituted of hornblende, muscovite and graphite schist. They are intruded by granodiorites and late to post granitic dykes (Adekoya, 1998; Kankara, 2014). The alterations are strongly potassium and calcium enriched pyrophyllite, kaolinite, illite and quartz also occurs. The main ore minerals are gold, chalcopyrite, arsenopyrite, pyrite, galena and iron oxides.

### **Undifferentiated gneiss-granite**

Structural features such as quartz veins, joints and foliations all have a general N-S orientation. Granite gneiss are extensive within the area, especially at the central portion. Para-gneiss, as sometimes can be called shows mineralogy and texture indicating derivation from a sedimentary rock protolith. Typically consisting of abundant quartz, mica, alumina silicate minerals, Para-gneiss within the mapped area occur mainly at contact between quartz schist and Granite gneiss.

### **Field Petrologic Description of Lithological Units**

The schist units occur with fine to medium, flat, sheet-like grains in a preferred orientation. The veinlets are concordant and parallel to the foliation with a 0.05cm to 10 cm width. Occurrence of Pelitic schist is relatively rare within the mapped area. However Quartz schist are abundant within the South eastern parts and are associated with intense lateralization.



Plate 1: Highly jointed quartzite vein



Plate 2: Typical quartz vein



Plate 3: Typical kaolinization process



Plate 4: Typical phyllite along a stream



Plate 5: Low-lying migmatite-granite-gneiss



Plate 6: Crushed gold-chalcophiles-bearing rocks

### Granite gneiss

Tracts of the area is underlain by poorly exposed and weathered gneisses often in association with the migmatites. It sporadically occur in pockets within porphyritic biotite granite and migmatite along many traverses, say at the western portion of the leased area.

They are light to dark coloured rocks which has gneissic foliation defined by felsic and mafic minerals. They consist of a heterogeneous group predominantly of granodioritic composition and varying degree of foliation. The textural variations in these rocks are because of different textures and proportion of K-Feldspar porphyroblast which contained in them. In some locations the feldspar porphyroblast are numerous and fairly large, up to 2-3cm, well linedated large-shaped tablets. The gneisses consist of an alternation of a micaceous laminae and more coarsely crystalline laminae of quartz and feldspar intergrowth. The granite gneiss occurs as low lying ridges along river valleys. This relationship is more frequently observed where migmatite and gneiss have a gradational contact. It is worth noting that apart from the basement outcrops there are other basement outcrop of small exposure of a highly weathered low-lying biotite-rich granite gneiss ridge.

### Porphyritic Biotite Granite (PBG)

Lithology, distribution and field relationship have shown that part of the area, especially to the north and northwest is underlain by grey to pink coloured granitoids, which occur as inselbergs and low lying whale-backs. Physical relations (example, sharp contacts) show clearly that porphyritic biotite granites in the study area were emplaced as liquid melts, and that the fine-medium grained varieties are older than the porphyritic varieties (plate 3). In addition to that, structural grain that dip in north-southdirection in the eastern neighbouring sheets has influenced the surfacing of phorphiritic granites. (Plate 5).

### Microgranites

Microgranites and medium to coarse grained granites are found to occur occasionally, however their limited exposure make them unmappable units. They spread to the upper north end, at the northern part of the leased portion. They occupy about 10% of the total area. The outcrops form low ridges in some places, and are aligned in NE-SW and probably have gradational boundaries with the strongly linedated, pink-grey rocks with an even-grained texture coarser than in the other gneisses. (Plate 5).

## **Structural Features**

### **Quartz Vein and Quartz fragments**

Plate 1 shows a highly jointed quartzite vein. Quartz veins occur in different dimensions in different parts within the mapped areas, quartz vein occurring within the mapped area are mostly whitish showing little or no vugs or alteration. Quartz ridges were observed at the south eastern parts and at the south western parts. The ridges are associated this quartz schist and areas within these ridges are also associated with intense silification. Quartz fragments were observed to be rare within the gneiss and more abundant within schist (see Plate 2).

### **Quartzo-feldspathic Veins and Aplite Dykes**

Aplites are light coloured hypabyssal igneous rocks. Both the aplite dyke and the quartzo-feldspathic veins intrude the Gneiss, concordantly and discordantly cross-cutting the intruded lithology

### **Pegmatite Veins**

Pegmatitic veins which constitute primary hosts to gold mineralization in northern Nigeria occur in the outcrops, varying from 5-30cm in width and spreading throughout the length of about 50m of most outcrops. These structural features explain the intensity of metamorphism resulting in secondary deformation by the gradational transition into the granites as they become more porphyroblastic with the increase in microcline content. (see Plate 4) The ideal composition of a granite (from hand specimen) is quartz+alkali feldspar+plagioclase feldspar. The Porphyritic biotite granite outcrops frequently in the NW of the portion, NS, and are devoid in the further east. Plate 3 indicates kaolinization process which signifies the existence of kaolinitic clays in the heart of the study area.

### **Alluvium Deposits**

These are deposits of gangues which may, or may not have contained gold granules and, or dusts derived from weathering and erosion of the surrounding rocks and which have been transported and deposited along many stream and river channels.

## **Geochemistry and Geochemical Interpretation of Results**

The elements Au, Ag, Pb, Ni, Cu, Zn, Mn, Cr, Ca and Co were measured in Part Per Million (ppm), while Fe, Na and K were measured in percentages (%). Table 1 shows the elemental concentration.

The computed threshold values for Au in the rock samples is 0.07ppm, while the computed threshold values for the sediments is 0.11ppm. These values are lower than the maximum recorded values of Au in the rock samples of 0.09ppm and the stream sediments of 0.137ppm. (Table 2 and 3). The minimum and maximum values are as follows: Au (bdl - 0.09ppm), Ag (0.37 - 0.97ppm), Pb (bdl - 86.64ppm), Ni (21.48 - 9268.30ppm), Cu (bdl - 189.13ppm), Zn (12.93 - 139.76ppm), Mn (141.30 - 1533.60ppm), Cr (15.56 - 2630.90ppm), for the rock samples. The sediments have Au (0.013 - 0.137ppm), Ag (0.09 - 0.23ppm), Pb (bdl -35.74ppm), Cu (6.02 - 104.41ppm), Zn (22.12 - 87.62ppm), Mn (0.25 - 1849.2ppm) and Co (3.5 - 73.39ppm). Au mineralisation in the rock samples is 0.09ppm with a concentration of 0.137ppm in the sediments. Omanayin and Ogunbajo (2016) in a similar study also reported an Au mineralisation of 0.16ppm in the rock samples and 0.23ppm in the sediments, showing a higher Au mineralisation in sediments than in the rock samples.



Table 1: Element concentration of rock/sediments samples analysed

Sample ID	Latitude	Longitude	Au	Ag	Pb	Ni	Cu	Zn	Mn	Cr	Ca	Fe	Na	K	Co	LOI	
Rock Samples	RW 001	12°36'21.42"	7°36'45.45"	0.0868	0.6699	57.17	107.24	10.97	23.84	187.04	144.81	1439.3	4.37	0.3	0.07	-	1.7
	RW 002	12°36'22.01"	7°36'44.93"	0.0297	0.4304	80.47	21.48	26.22	27.44	299.52	15.56	949.3	9.23	0.4	0.46	-	14.1
	RW 003	12°36'21.48"	7°36'45.95"	0.0211	0.9673	86.64	199.52	ND	87.85	251.8	297.03	1947	4.47	0.22	1.6	-	1.2
	RW 004	12°36'21.54"	7°36'42.77"	0.0491	0.7762	ND	111	ND	12.93	141.3	94.01	1837.59	1.95	0.73	0.29	-	6.9
	RW 005	12°36'10.55"	7°35'59.01"	ND	0.8481	ND	155.68	56.42	46.58	1070.5	328.96	848.63	47.78	0.26	0.29	-	5.5
	RW 006	12°36'12.97"	7°36'00.23"	0.01	0.61	3.59	9268.3	189.13	23.64	1533.6	2630.9	846.42	19.57	0.18	0.09	-	4.7
	RW 007	12°36'14.71"	7°36'01.64"	0.0683	0.3651	1.74	258.55	48.69	139.76	797.11	593.83	1354.43	20.88	0.22	0.68	-	12.3
Sediments	RW 008	12°36'14.75"	7°35'02.95"	0.087	0.089	4.24	-	9.39	22.12	472.7	-	-	4.97	-	-	5.88	-
	RW 009	12°36'22.02"	7°35'20.95"	0.0978	0.088	7.66	-	13.33	27.72	541.43	-	-	9.39	-	-	7.51	-
	RW 010	12°36'23.20"	7°35'31.34"	0.0127	0.0889	4.22	-	21.11	29.78	390.99	-	-	12.07	-	-	6.83	-
	RW 011	12°35'13.34"	7°35'29.24"	0.0958	0.1157	ND	-	6.02	28.01	1026.9	-	-	13.87	-	-	7.79	-
	RW 012	12°35'13.34"	7°35'29.24"	0.0231	0.0934	35.74	-	49.8	45.26	0.25	-	-	14	-	-	11.86	-
	RW 013	12°36'43.99"	7°36'09.57"	0.0793	0.1348	ND	-	19.06	52.64	934.28	-	-	1.44	-	-	7.28	-
	RW 014	12°36'00.23"	7°36'10.48"	0.0948	0.1364	26.49	-	38.84	32.07	1849.2	-	-	11.79	-	-	12.92	-
	RW 015	12°36'09.88"	7°36'22.33"	0.08	0.229	ND	-	13.81	87.62	0.66	-	-	21.93	-	-	51.6	-
	RW 016	12°35'30.24"	7°35'19.41"	0.1368	0.1957	1	-	7.27	47.13	420.94	-	-	1.46	-	-	3.5	-
	RW 017	12°36'18.56"	7°36'05.90"	0.0565	0.2026	12.26	-	104.41	84.01	0.65	-	-	18.26	-	-	73.39	-

RW 001 – RW 017 = Rawayau, sampling points 001 to 017. All units are in ppm. Fe, Na, K and LOI are in %.

Table 2: Geochemical threshold values for rock samples.

Sample No.	Min	Max	Range	Mean	Median	St. Dev.	Med. Abs. Dev. (MAD)	Med. + 2*MAD. (Threshold)
<b>Au</b>	7	0.00	0.09	0.09	0.04	0.03	0.03	0.07
<b>Ag</b>	7	0.37	0.97	0.60	0.67	0.67	0.22	1.03
<b>Pb</b>	7	0.00	86.64	86.64	32.80	3.59	40.28	10.77
<b>Ni</b>	7	21.48	9268.30	9246.82	1445.97	155.68	3450.14	252.56
<b>Cu</b>	7	0.00	189.13	189.13	47.35	26.22	66.38	78.66
<b>Zn</b>	7	12.93	139.76	126.83	51.72	27.44	46.08	56.46
<b>Mn</b>	7	141.30	1533.60	1392.30	611.55	299.52	535.94	615.96
<b>Cr</b>	7	15.56	2630.90	2615.34	586.44	297.03	921.35	703.07
<b>Ca</b>	7	846.42	1947.00	1100.58	1317.52	1354.43	458.31	2320.75

Table 3: Geochemical threshold values for sediments

Sample No.	Min	Max	Range	Mean	Median	St. Dev.	Med. Abs. Dev. (MAD)	Med. + 2*MAD. (Threshold)
<b>Au</b>	10	0.013	0.137	0.124	0.076	0.084	0.037	0.110
<b>Ag</b>	10	0.088	0.229	0.141	0.137	0.125	0.053	0.198
<b>Pb</b>	10	0.000	35.740	35.740	9.161	4.230	12.408	12.690
<b>Cu</b>	10	6.020	104.410	98.390	28.304	16.435	30.246	32.645
<b>Zn</b>	10	22.120	87.620	65.500	45.636	38.665	23.349	60.265
<b>Mn</b>	10	0.250	1849.200	1848.950	563.800	446.820	578.782	1339.150
<b>Co</b>	10	3.500	73.390	69.890	18.856	7.650	23.721	13.570

Min = Minimum; Max = Maximum; Med = Median; St. Dev. = Standard Deviation; MAD = Median Absolute Deviation

Significant positive correlation is observed between Ni and Cr ( $r = 0.98$ ), Cu ( $r = 0.94$ ), Mn ( $r = 0.77$ ); Cu and Cr ( $r = 0.96$ ), Mn ( $r = 0.92$ ); Mn and Cr ( $r = 0.83$ ) in the rock samples. (Table 4), while for the sediments, significant correlation exists between Ag and Zn ( $r = 0.86$ ), Co ( $r = 0.70$ ); Co and Cu ( $r = 0.72$ ), Zn ( $r = 0.87$ ). (Table 5). The high correlation between Co, Mn, Zn, and Ni may suggest paragenetic co-occurrence of the two elements. (Simmonds *et al.*, 2017; Fagbohun *et al.*, 2021). A moderate positive correlation exists between Au and Ca ( $r = 0.42$ ). Au has negative correlation with Mn ( $r = -0.54$ ), Cu ( $r = -0.44$ ), Ag ( $r = -0.39$ ), Ni ( $r = -0.39$ ) and Cr ( $r = -0.37$ ) for the rock samples while showing a moderate positive correlation between Au

and Ag ( $r = 0.34$ ) in the sediments. An Au/Ag correlation in sediments sample was reported in a similar study. (Woguia *et al.*, 2021). Au also recorded positive correlation with Mn ( $r = 0.38$ ) and negative correlations with Pb ( $r = -0.40$ ) and Cu ( $r = -0.43$ ) respectively.

Table 4: Correlation matrix for the elemental concentration in the rock samples

	<i>Au</i>	<i>Ag</i>	<i>Pb</i>	<i>Ni</i>	<i>Cu</i>	<i>Zn</i>	<i>Mn</i>	<i>Cr</i>	<i>Ca</i>
<i>Au</i>	1								
<i>Ag</i>	-0.39	1							
<i>Pb</i>	0.08	0.12	1						
<i>Ni</i>	-0.39	-0.11	-0.33	1					
<i>Cu</i>	-0.44	-0.25	-0.46	<b>0.94</b>	1				
<i>Zn</i>	0.17	-0.23	-0.03	-0.25	-0.12	1			
<i>Mn</i>	-0.54	-0.16	-0.59	<b>0.77</b>	<b>0.92</b>	0.09	1		
<i>Cr</i>	-0.37	-0.14	-0.40	<b>0.98</b>	<b>0.96</b>	-0.08	<b>0.83</b>	1	
<i>Ca</i>	0.42	0.44	0.27	-0.45	-0.67	0.21	-0.71	-0.44	1

Table 5: Correlation matrix for the elemental concentration in the sediments

	<i>Au</i>	<i>Ag</i>	<i>Pb</i>	<i>Cu</i>	<i>Zn</i>	<i>Mn</i>	<i>Co</i>
<i>Au</i>	1						
<i>Ag</i>	0.34	1					
<i>Pb</i>	-0.40	-0.26	1				
<i>Cu</i>	-0.43	0.27	0.51	1			
<i>Zn</i>	-0.09	<b>0.86</b>	-0.08	0.52	1		
<i>Mn</i>	0.38	-0.25	0.09	-0.26	-0.52	1	
<i>Co</i>	-0.19	<b>0.70</b>	0.02	<b>0.72</b>	<b>0.87</b>	-0.46	1

For the rock samples, sampling location (RW 001) recorded the highest Au concentration with the lowest Au concentration in RW 005. The highest Ag mineralisation for the rock samples was recorded in RW 003 and the lowest concentration in RW 001. (Fig. 4). Au recorded its highest concentration in RW 016 while its lowest concentration was recorded in RW 010, Ag concentration was highest in RW 015 with its lowest concentration recorded in RW 009 in the sediments. (Fig. 5). Ag showed higher concentration than Au at all sampling points for both rock and sediments except in location RW 009. These sampling points can be identified as Au and Ag targets for further exploration.

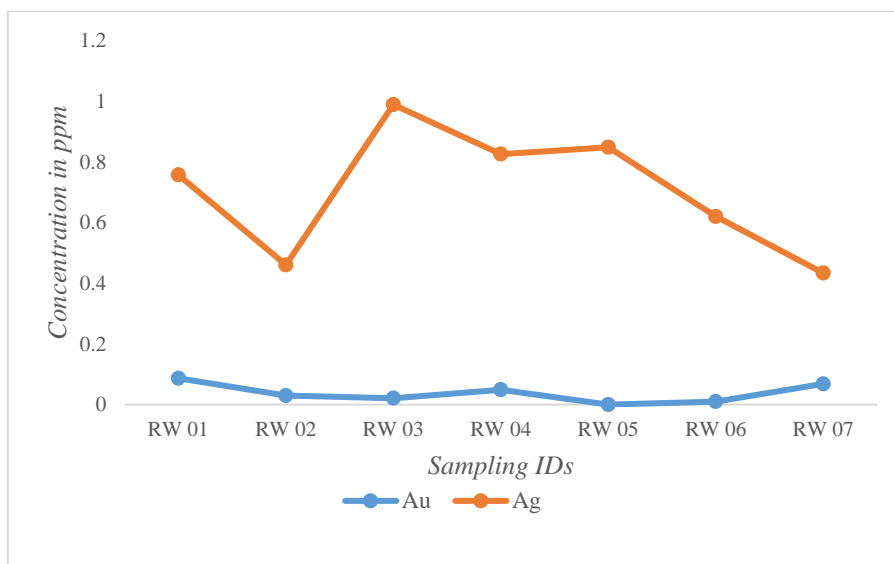


Fig 4: Concentration of Au & Ag in rock samples at various sampling points

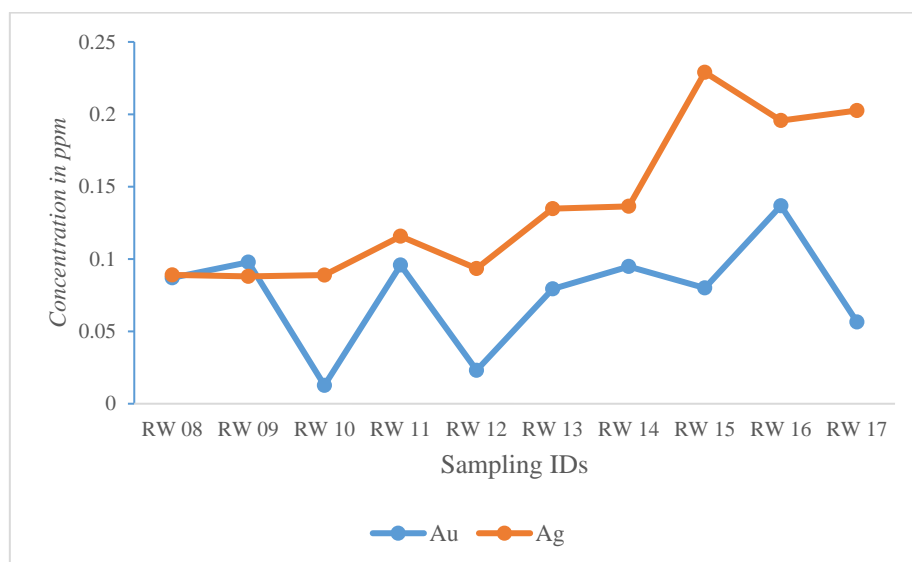


Fig 5: Concentration of Au & Ag in sediments at various sampling points

The gold and silver, which are the prime target, though had never had any much concentration on the surface as revealed by geochemical results and interpretations actually fall within the range values of the average concentrations of gold across the globe via geochemical background. From the geochemical results obtained, the composition of nickel, copper, zinc, manganese, chromium and lead are higher in concentrations, in comparison to the concentrations of gold and silver. A subsurface increment of Au and chalcophile concentrations of Ni, Cu and Zn was observed in the study area. Abiola *et al.*, (2017) also reported an increase in the grade of gold with depth in the Nasko gold deposit area. Haruna *et al.*, (2017) however, reported of a placer gold pattern that was more laterally distributed in the Karau-Karau schist belt.

The distribution of economic gold grade is not uniform but vary extensively within the concession.

Absence of artisanal working and physical properties of observed quartz veins, have made it difficult to say about the mineralization potential of these areas.

The importance of the study is that it provides information on the geochemical analysis on samples, with geological and other indicators, required for an exploration model and a better understanding of the potential of mineralization in the study area.

### **Conclusion**

In this study, the Gold and Chalcophile mineralisation potentials of the Rawayau area using the soil and stream sampling geochemical technique was investigated. The geochemical study and result interpretation revealed that the Au concentration ranged from below detection level (bdl) to 0.137ppm, while Ag concentration ranged from 0.09ppm to 0.97ppm, thus showing that Ag had a higher concentration in the study area than Au. The maximum values of Au in both the rock and sediments was higher than the corresponding computed threshold values. The correlation analysis revealed significant positive relationship between Ni, Cr, Cu, Mn, Fe, Zn and Co. A subsurface increment of Au and chalcophile concentrations of Ni, Cu and Zn was also observed in the study area with higher concentrations of Ni, Cu, Zn, Mn, Cr and Pb in comparison to Au and Ag. The findings of this study can be employed to generate the needed information for a detailed exploration that will lead to the commercial mining of gold and other minerals in the study area. It is believed that this will generate revenue for the government as well as provide employment for the inhabitants of the study area.

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