GEOCHEMICAL EXPLORATION FOR GOLD & ASSOCIATED ELEMENTS, IN THE J. MOYA AREA, SENNAR STATE , CENTRAL SUDAN.

Osman Abuagla Daffalla ,EL-Sheikh Mohammed Abdrahman , GRAS, Ministry of Minerals ,Sudan and Salih Ali Salih, Department of Mineral Wealth, Faculty of Oil & Minerals, Al-Neelain University, Sudan.

Keywords: Jebel Moya ,Sudan, Exploration for Gold.

ABSTRACT

The study area is located around Jebel Moya in Sennar State, central Sudan. The area is an important link between northern and southern terrains of the late Proterozoic Pan African Arabian Nubian Shied, which is characterized by exhalative volcanogenic massive sulphide deposits and associated Au and Ag metals in low grade volcano-sedimentary sequences. The objective of this study is to carry out geochemical exploration for gold and associated elements using stream sediments and soil geochemical methods, for the first time in the study area.

Previous geological investigations revealed the existence of low grade metasedimentary sequences, high grade granulite facies rocks, granitoid complexes around J. Moya at the center of the study area.

Au orientational geochemical survey has been conducted by the collection of 5 stream sediments samples in different grain size fractions (-63µ,-80µ,-125µ). This step is very important to select the effective fraction for further exploratory works. Sampling includes also collection of 14 chip composite samples. All samples have been analyzed for gold using wet analysis techniques with very low detection limits and ICP- ms techniques for associated elements in OMAC laboratories. Results of this work revealed that the best grain size to be used in regional geochemical survey in this area is(-63µ). This grain size yield high element values for Au, As, Ba, Cr, Th, Ti, U, V and Zn in the stream sediments samples. Chip samples also recorded high concentrations of Au, As, Ba, Fe, S, Pb, V, Zn, U, Th.

Anomalies have been followed up by chip samples from the catchment areas. Eaight gossanic bodies have been reported for the first time in the

study area. Chip samples recorded up to 0.9g\t gold and 0.6% Zn in the gossans and up to 19 ppm U. Further work is recommended including covering the whole of the area with a low density stream sediment geochemical survey using (-63µ fraction) as the optimum size. Detailed exploration work including trenching and later drilling is recommended for the gossanic bodies.

Introduction:

The J. Moya area is located in the central part of the Sudan, about 250km from Khartoum. This area witnessed the first cement factory in Sudan for the construction of Sennar Dam in 1925.The area investigated is about 2553 Km2 largely bounded by Longs. 32° 50´–33° 24´E, and Lats. 13° 20´–13° 45´N (**Fig.1**).

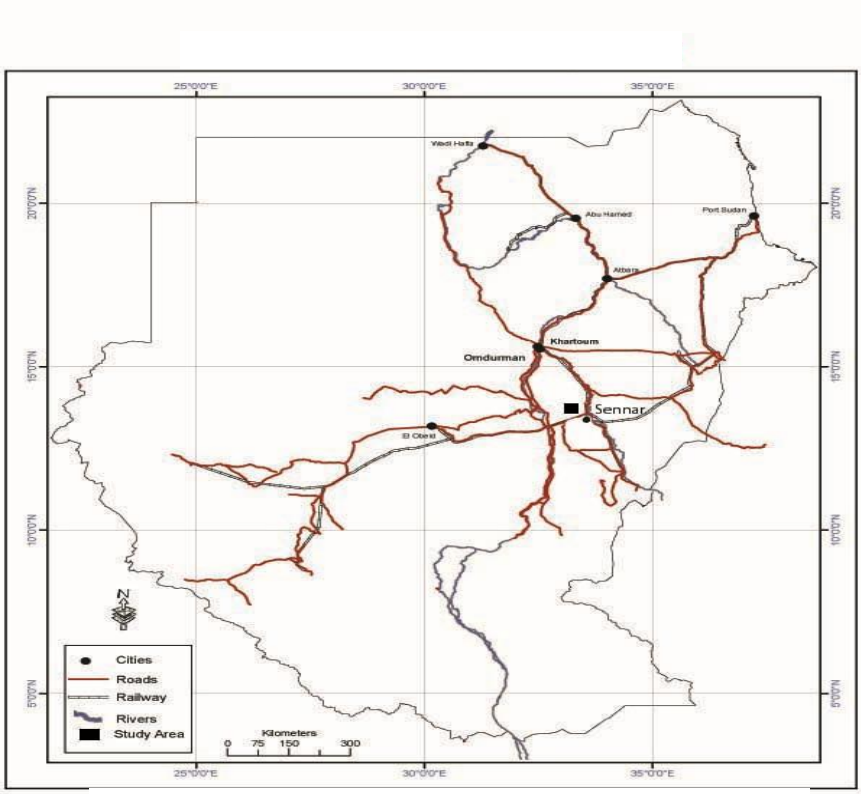


Fig. 1 :Location map of the study area

Geology of the area:

Most of previous researchers concentrated on the geochronology and regional geology and building materials in the J. Moya area.

Ruxton (1956) studied the geology of Sennar and El-Gadarif areas; Iskander (1957) studied the areas between Sennar and J. Dud to the west, and northern part of J. Saqqadi up to J.Sireg to the south. The purpose of the study is to investigate the marble outcrops suitable for cement industries. Charnokitic pyroxene granite had been reported by Kabesh **(**1967) and Vail (1982). Whiteman (1971) concluded that the granite intruded the charnockite. Vail **(**1976) outlined the distribution of green schist assemblage rocks. Charnockite and granitic enderbite have been described by (Stern and Dawood ,1991). Hirdes and Brinkmann (1985); Abdelsalam and Dawood (1991) Considered that the basement rocks between the Blue Nile and White Nile may constitute a terrain bounded to the west by the Kabus suture and to the east by the Qala El-Nahal – Ingessana Hills Suture.

Alternatively Vail (1985) & Kroner et. Al. (1987) suggested that the J. Moya area may be an extension of one of the Terrenes identified in the Arabian Nubian Shield.

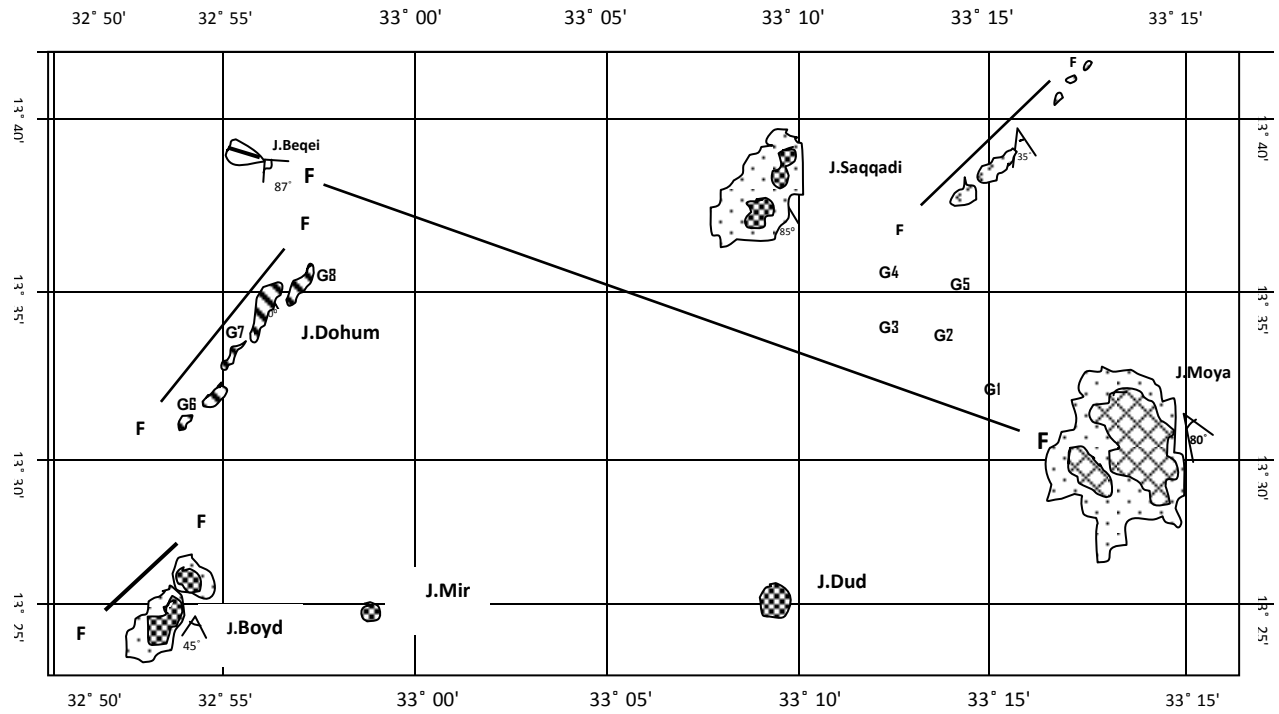
Bashir and Dawoud (1993) conducted that granulite faciese metamorphism in J. Moya occurred around 740Ma. This age according to the same authors, is typical of Mozambique Belt which extends northward to include J. Moya and Sabaloka area in the north. Radioactive appraisal carried out by Gindy et al. 1995.

The only work which broadly addressed the mineral potential of this area, has been recently carried out by Elgilani et. al**.** **(**2007). Therefore, the objective of the present study is to

conduct a cost and time effective geochemical survey to provide base line information on the mineral potentialities of this geologically favorable terrain.

J.Moya area comprises isolated hilly outcrops stand over wide plain covered by clay (Fig.2). The main rock groups include various lithologies of the basement complex, represented by charnockites and granulites as the oldest rocks in the region and are extremely rare in the Sudan. The former are overlain by a low grade Pan-African volcanosedimentary sequence and intruded by granites of various types, beside recent sediments dominated by cotton soil of Pleistocene age.

Fig.No.2 Geological map of J.Moya and adjacent areas



Scale: 1: 150 000

	Colluvium
	Umm Rawaba Formation
	Granite
	Marble
	Quartizites
	Charnockite and Enderbite rocks

	Quarz Vein
G1 TO G8	Iron Caps (Gossans)

As already mentioned the study area has not been mapped in details, nevertheless previous workers have subdivided the regional geology into Precambrian basement rocks and cover. The basement includes granulites facies, gneisses, amphibolites, low grade volcanosedimentary sequence (green schist assemblages), granites and gabbros. The cover comprises unconsolidated sediments (Fig.2).

Methods of investigation:

Remote Sensing techniques have been used in this work to process Land Sat images (scene number 173-51) in band (4,3,2) to produce geological, topographic and hydrographic base maps. Computer programs such as office (Word ,Excel ,…etc, Adobe Photoshop, GIS & Statistica have been used for data analysis, Available information has been compiled in the base maps.

Geological base maps to scale 1:150 000 have been prepared for seven localities in the study area, viz. ; J.Moya, J.Saqqadi, J.Dud, J.Al-Awar, J.Duhum, J.Begeira, Biyud hills.

GEOCHEMICAL INVESTIGATION

An orientational study has been carried out. At least 5 stream sediments samples (Geochems), have been collected from the area and sieved for three size fractions (-63µ,-80µ and -125µ) to determine the effective size fraction for the regional survey.

In each sample location, the sediments were collected from the sites represented by second and third order streams. Active sediments were locate by traversing across the channel. According to Flectcher and Day (1988c); Saxby and Flectcher (1986); McConnel et al.(1993) the active sediments are preferable in geochemical prospecting. About 200 to300 grams for each sample were collected and placed in plastic envelopes provided by the OMAC laboratory for this purpose. The location of each sample was documented using Garmin GPS 60cs.

Also rock samples have been collected from the area to improve the base geological maps. Samples preparation (crushing & milling) were carried out in the Geological Research Authority of Sudan (GRAS) Lab. Chemical analysis of the rocks and stream sediments were carried out in OMAC Labs. Trace elements were determined using aqua regia, ICP technique. The detection limits of different elements are shown in Table (1). Gold was determined using wet chemical techniques for stream sediments samples, the detection limits of the wet chemical techniques are 0.001ppb.

The analytical results of orientational study are given in Table (1). Size -63µ gave three positive average values of the five samples, while size -80µ & -125µ gave three negative average values, thus suggesting that size -63µ is the optimum and the best size for the low density regional stream sediment geochemical survey.

Low density survey

Based on the orientational study results the area of investigation has been geochemically surveyed at a density of 1sample/10 Km^2 (a low density geochemical survey).

During the first phase of sampling 29 stream sediment samples have been collected in fraction (-63µ) and analyzed for gold (Au1 1ppb) and ICP aqua regia for 46 elements.

The results of chemical analysis of grab (chip) samples are given in Table (2). Some of the stream sediments samples have high concentrations of elements such as Au, As, Ba, Cr, Th, Ti, U, V, Zn other elements show low concentrations as shown in Table (2). The concentrations of the above elements have been demonstrated graphically in Fig.(1) to Fig.(9) and are plotted as module of elements of stream sediments samples in Fig. (3).

Serial No	Sample No	Mesh Size in µm	Conc. ppb
1	S15.B.S	-63	N.D
2	S15.B.S	-80	N.D
3	S15.B.S	-125	2
4	S16	-63	N.D
5	S16	-80	N.D
6	S16	-125	N.D
7	S26	**-63**	4
8	S26	-80	2
9	S26	-125	4
10	S27	**-63**	4
11	S27	-80	2
12	S27	-125	4
13	S28	**-63**	2
14	S28	-80	N.D
15	S28	-125	N.D

Table.1: Analytical results of orientational study.

Fig.3A Analytical results of orientational study

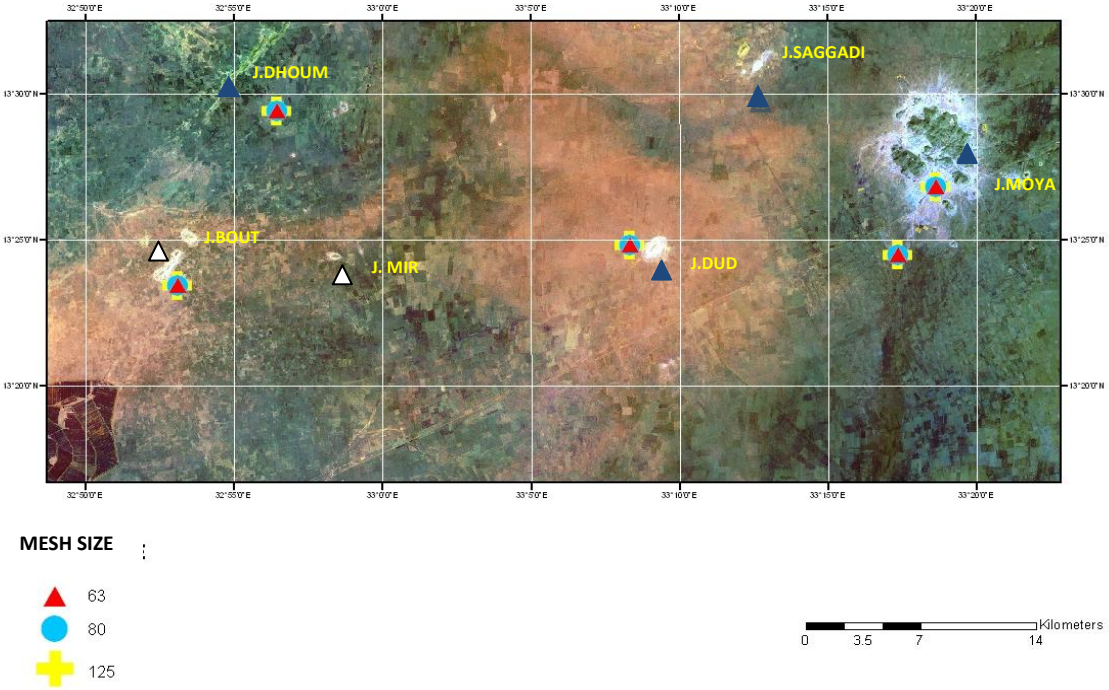


Fig.3B Analytical results of orientational study

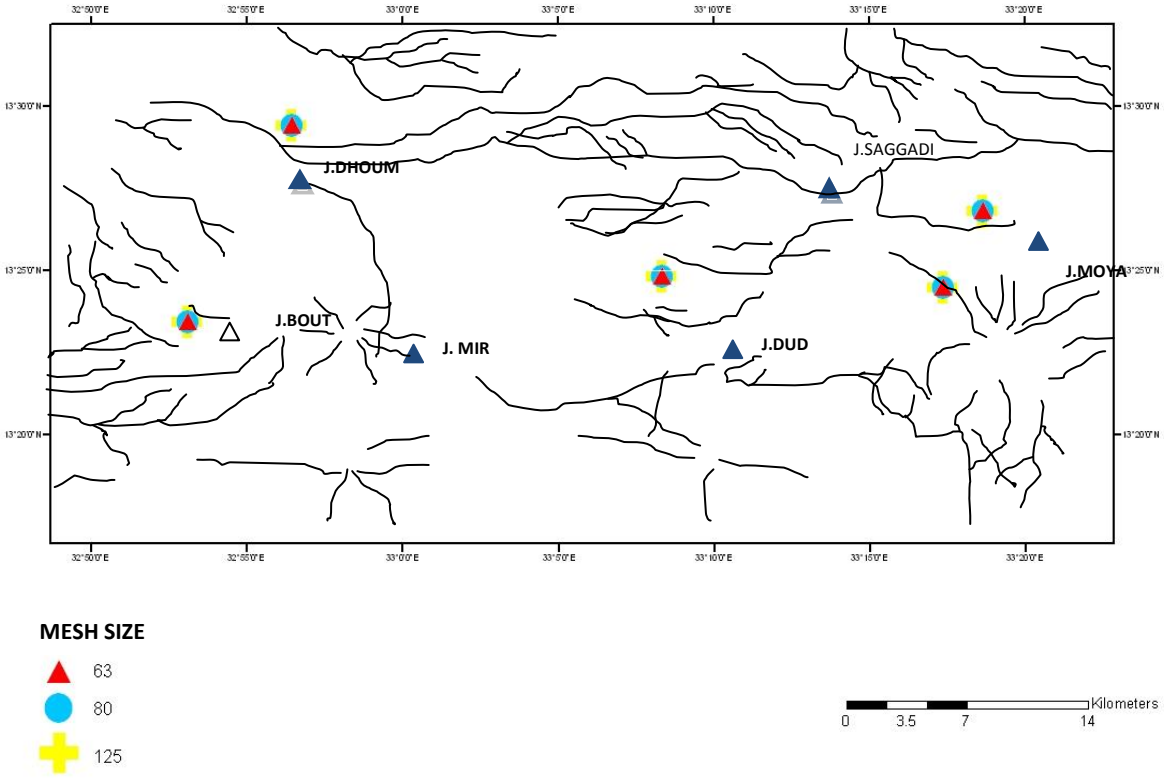
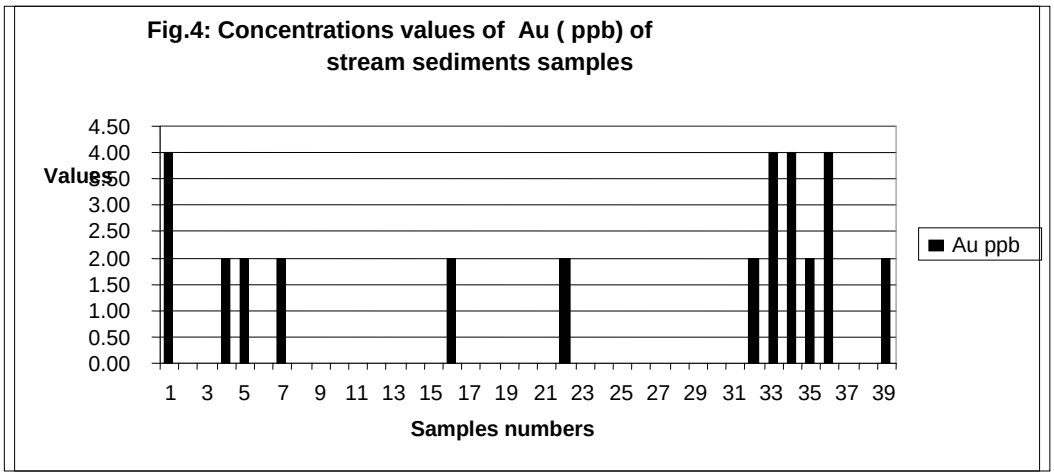


Table.2: Maximum and Minimum values of gold and associated elements of Stream sediments samples.

Element detector	Max	Min	Average
Au ppm	0.90	0	0
Au ppb	4.00	0	0
As ppm	6. 12	0.26	4.35
Ba ppm	478.22	42.80	256.08
Cr ppm	118.91	9.29	71.82
Thppm	26.82	5.27	8.76
Ti ppm	2606.8 4	827.28	1286.34
U ppm	9.56	5.83	7.69
V ppm	208.71	33.35	92.64
Zn ppm	156.96	22.26	64.23



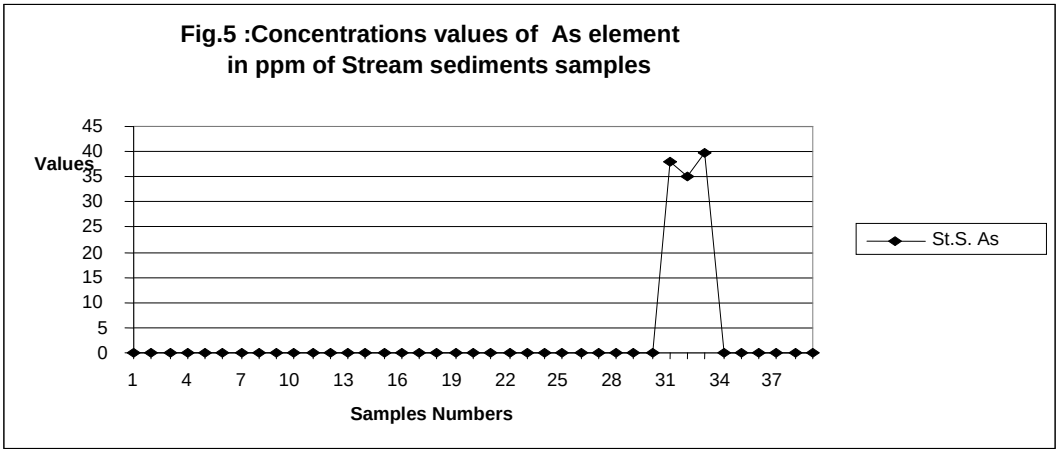


Fig.5 :Concentrations values of As element in ppm of Stream sediments samples
Values
45
40
35
30
25
20
15
10
5
0
1 4 7 10 13 16 19 22 25 28 31 34 37
Samples Numbers
St.S. As

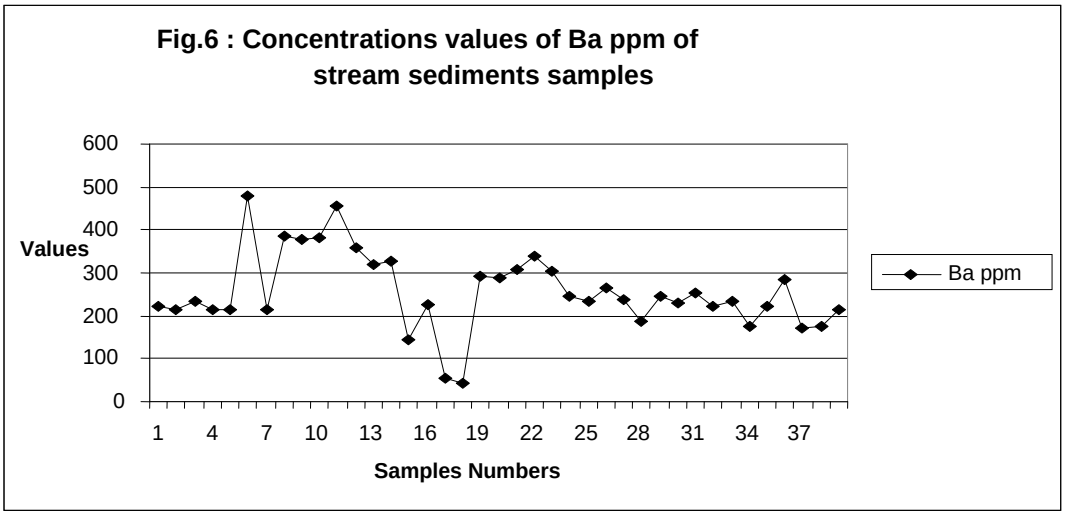


Fig.6 : Concentrations values of Ba ppm of stream sediments samples
Values
600
500
400
300
200
100
0
1 4 7 10 13 16 19 22 25 28 31 34 37
Samples Numbers
Ba ppm

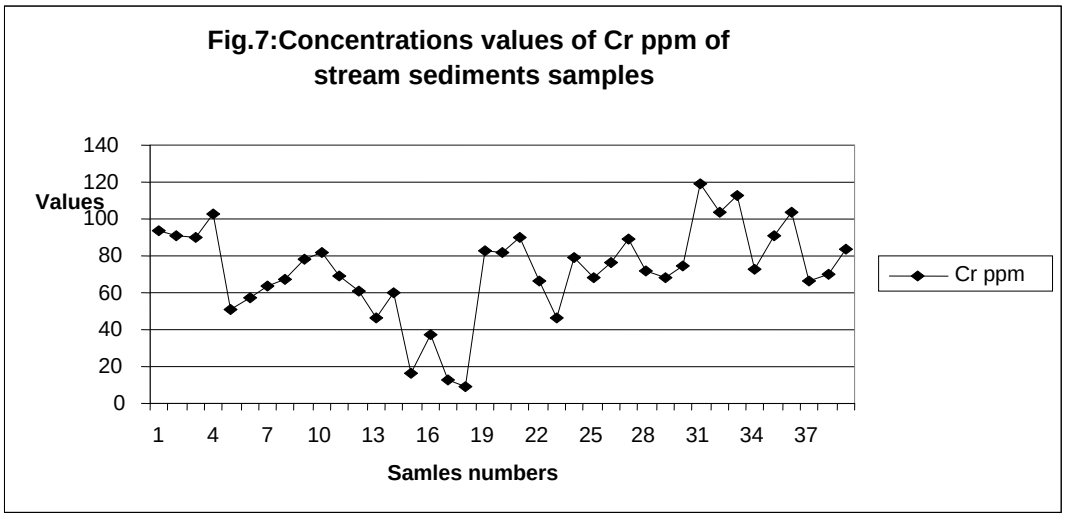


Fig.7:Concentrations values of Cr ppm of stream sediments samples
Values
140
120
100
80
60
40
20
0
1 4 7 10 13 16 19 22 25 28 31 34 37
Samles numbers
Cr ppm

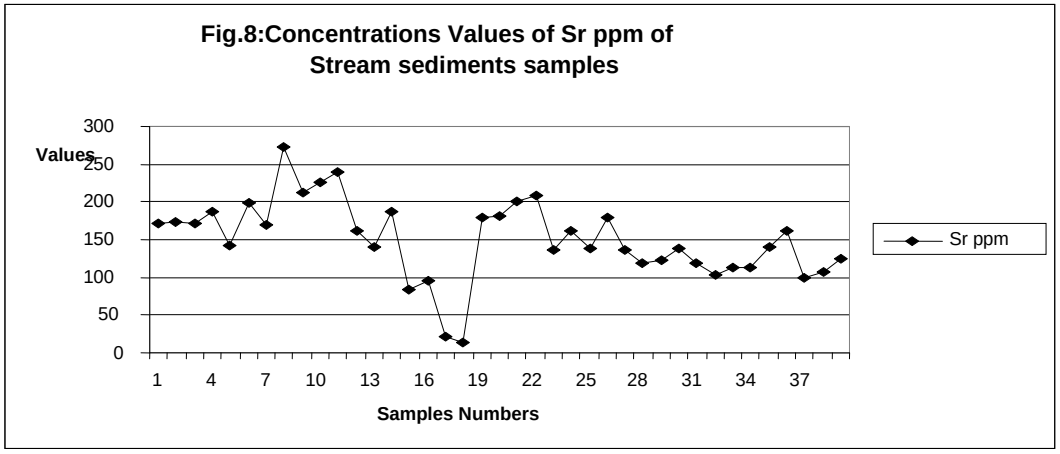


Fig.8:Concentrations Values of Sr ppm of Stream sediments samples
Values
300
250
200
150
100
50
0
1 4 7 10 13 16 19 22 25 28 31 34 37
Samples Numbers
Sr ppm

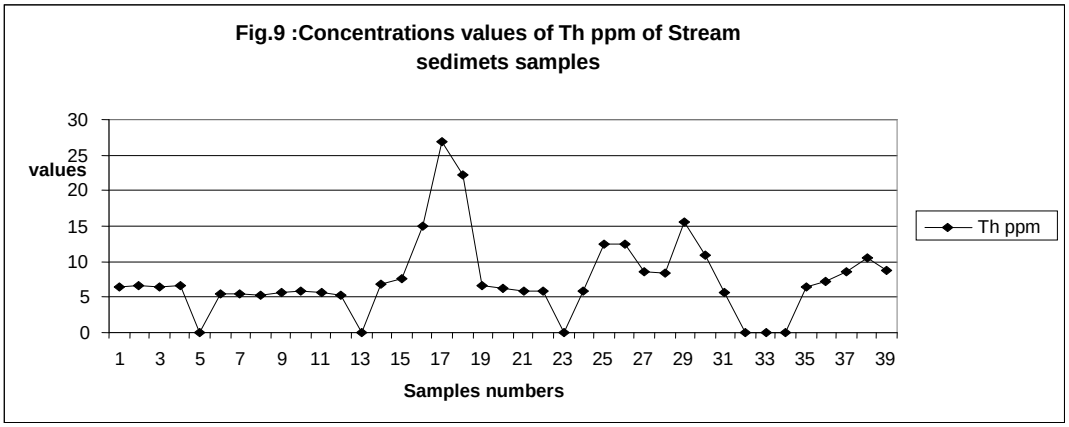


Fig.9 :Concentrations values of Th ppm of Stream sedimets samples
values
30
25
20
15
10
5
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39
Samples numbers
Th ppm

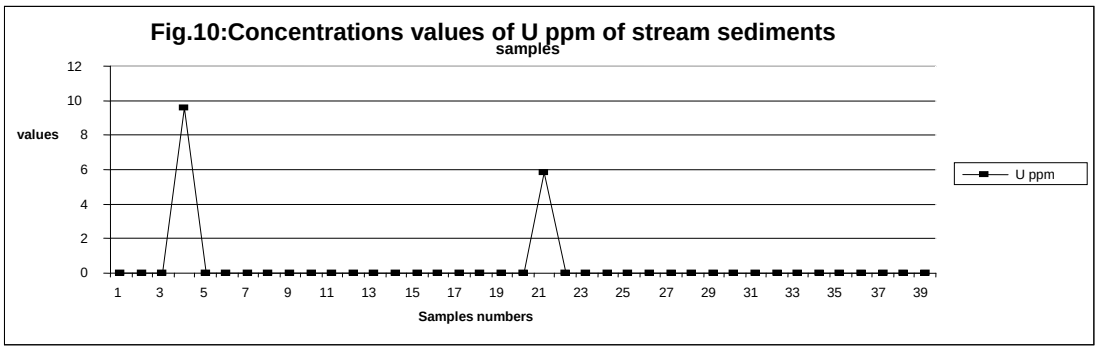


Fig.10:Concentrations values of U ppm of stream sediments
samples
values
12
10
8
6
4
2
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39
Samples numbers
U ppm

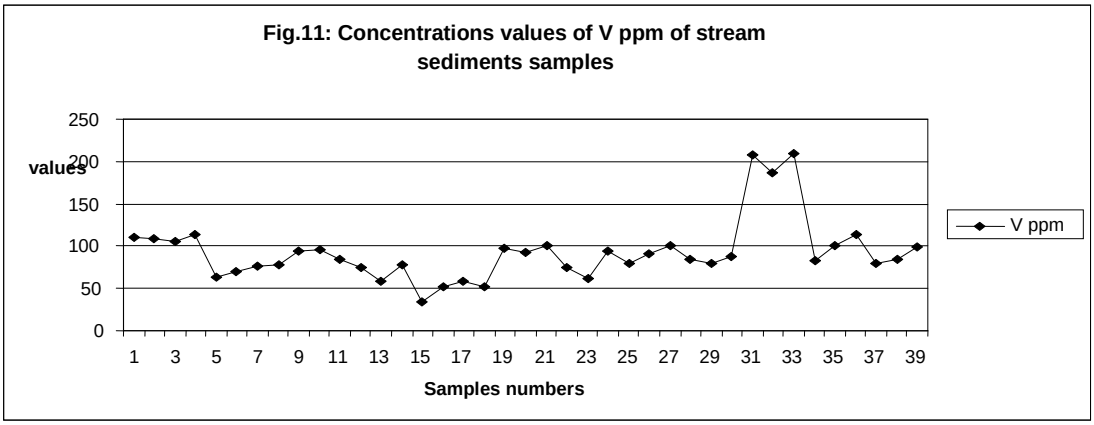
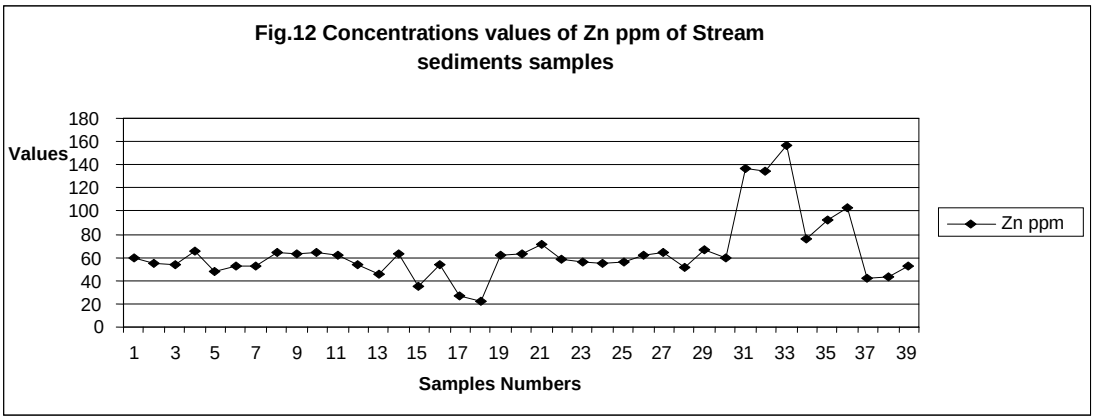


Fig.11: Concentrations values of V ppm of stream sediments samples
values
250
200
150
100
50
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39
Samples numbers
V ppm



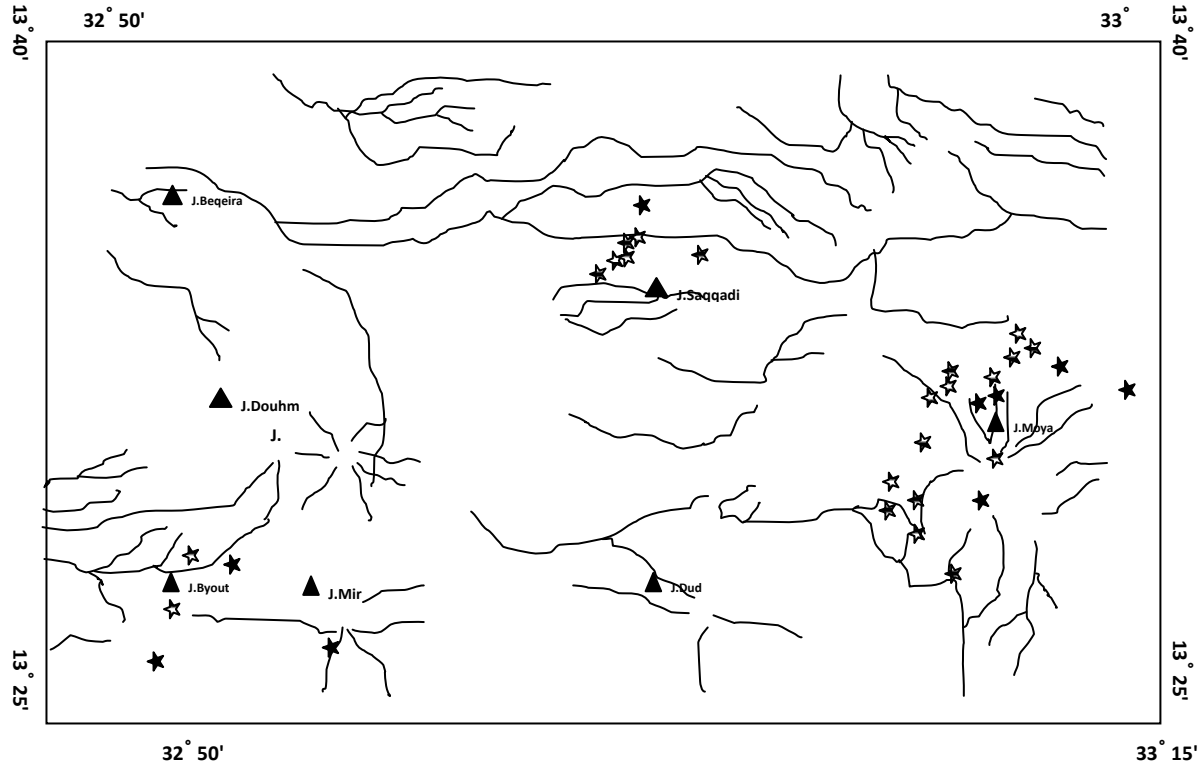


Fig.13 Distribution of Au (ppb) stream sediments of J.Moya area

Chip samples

-Mineralization Criteria of Gossans:

14 chip samples have been taken from different localities of outcrops within study area to be analyzed for gold and associated elements. The samples have been prepared (Crushing & Milling) and then sent to OMAC Lab. for chemical analysis. The results of the chip samples confirm mineralization relating to gossanic bodies located for the first time in the study area.

The analytical results of the chip samples have shown the presence of many elements such as gold especially in the gossans associated with Fe, Pb, V, Zn (Diagrams, Fig.(14) to Fig. (21)). Also the results confirm the radioactive elements (U&Th) in some locations as indicated by the chip samples (Diagrams, Fig. (22) and Fig.(23)). The distribution of concentrations of gold is plotted on Fig. (24). The gold concentration in the gossanic formations are shown in Fig. (2).

Fig.14: Concentrations values of Au ppb of Chip samples

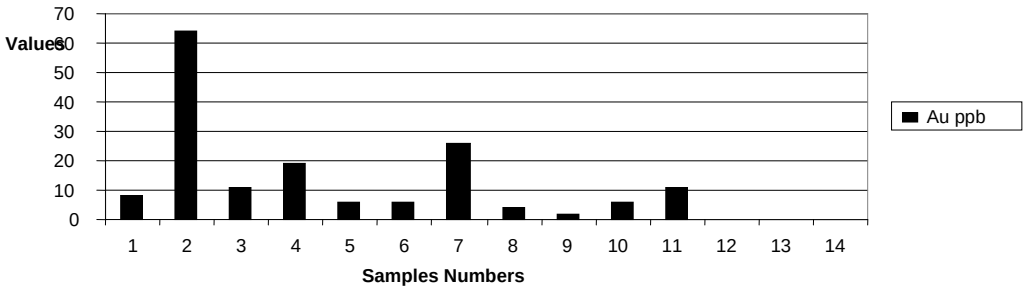


Fig.15:Concentrations values of As ppm of Chip samples

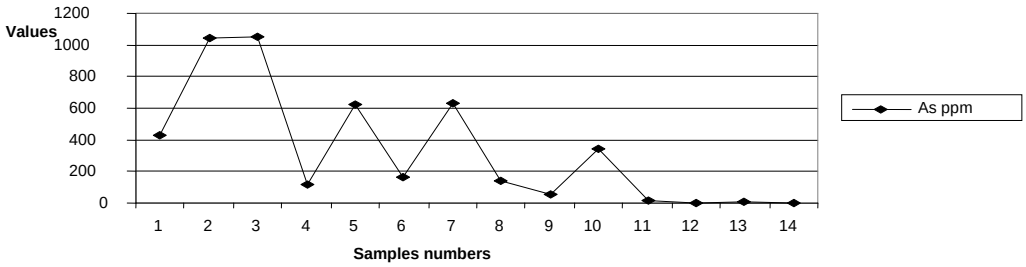


Fig.16: Concentrations values of Ba ppm of Chip samples

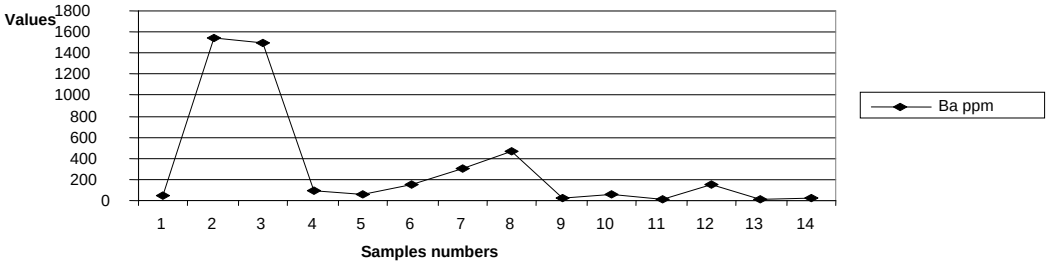
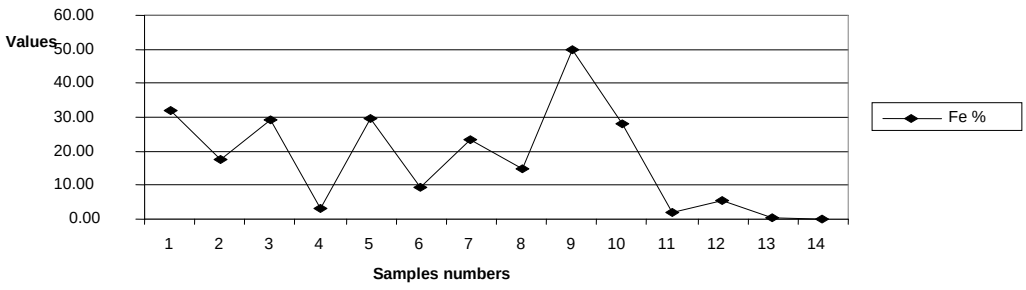


Fig.17:Concentrations values of Fe % of Chip samples



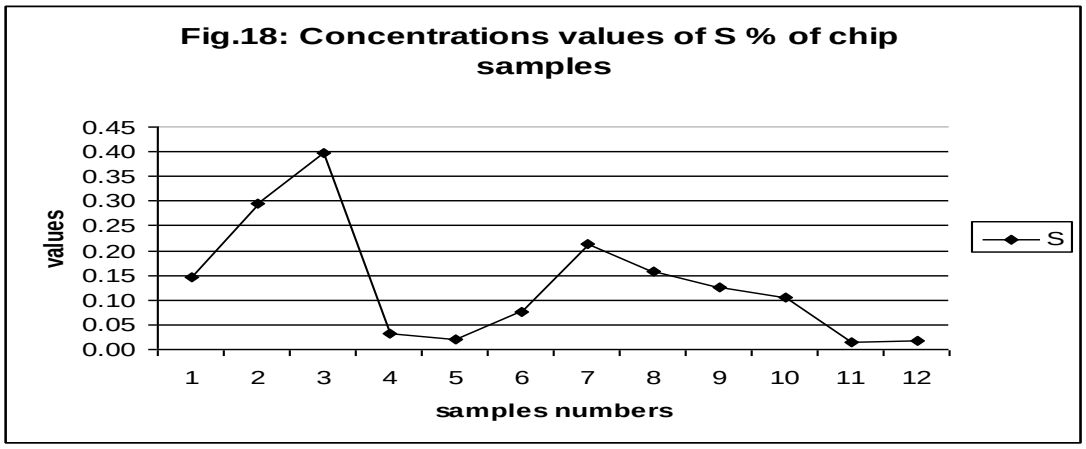


Fig.18: Concentrations values of S % of chip samples
values
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1 2 3 4 5 6 7 8 9 10 11 12
samples numbers
S

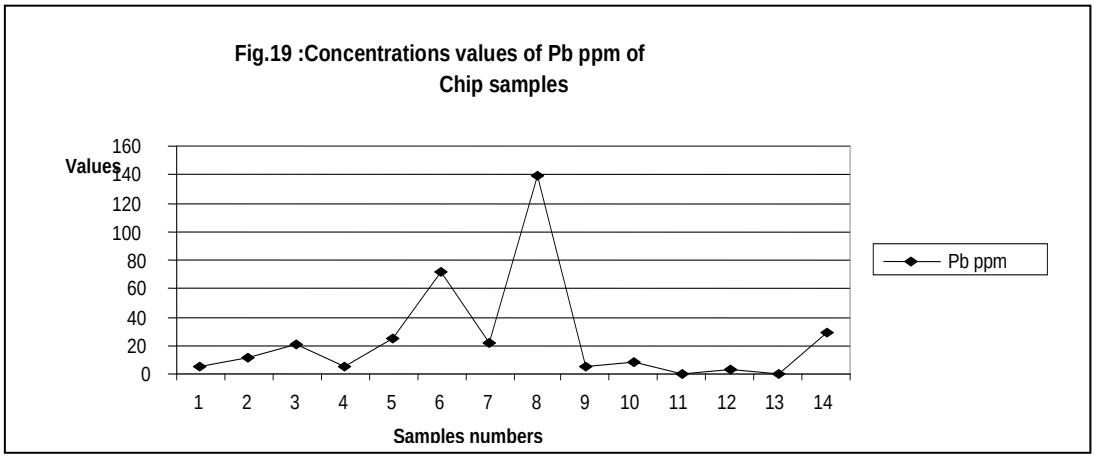


Fig.19 :Concentrations values of Pb ppm of Chip samples
Values
160
140
120
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Samples numbers
Pb ppm

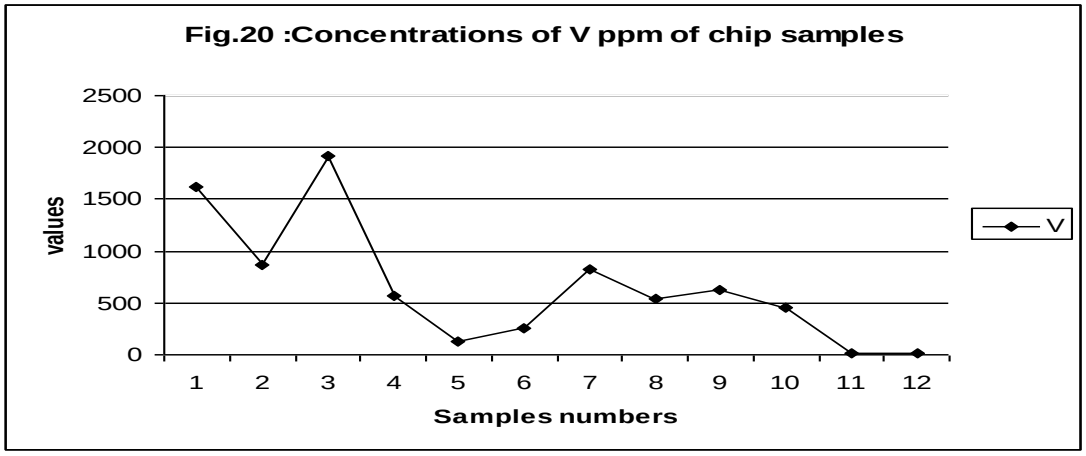


Fig.20 :Concentrations of V ppm of chip samples
values
2500
2000
1500
1000
500
0
1 2 3 4 5 6 7 8 9 10 11 12
Samples numbers
V

Fig.21:Concentrations values of samples

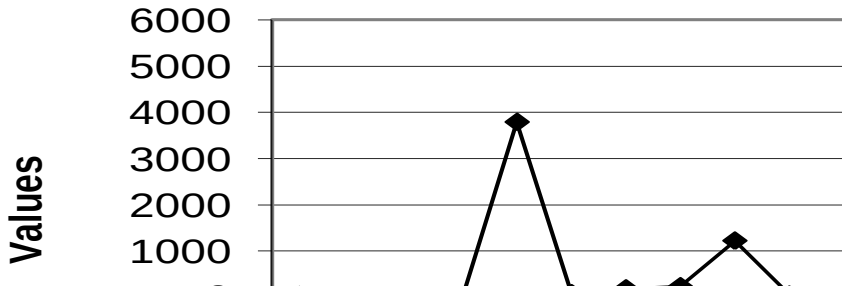


Fig. 22 :Concentration values of Th ppm of chip samples

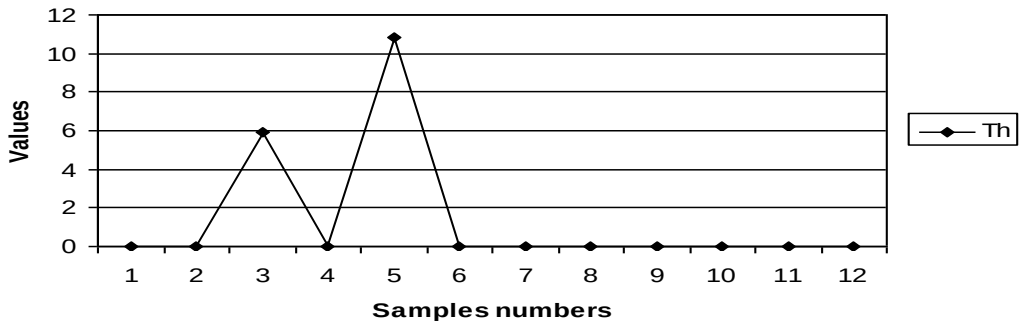
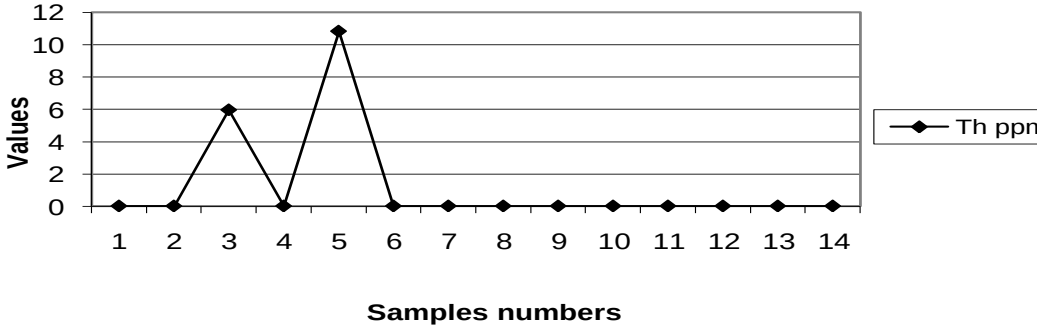


Fig.22: Concentrations of Th ppm of Chip samples



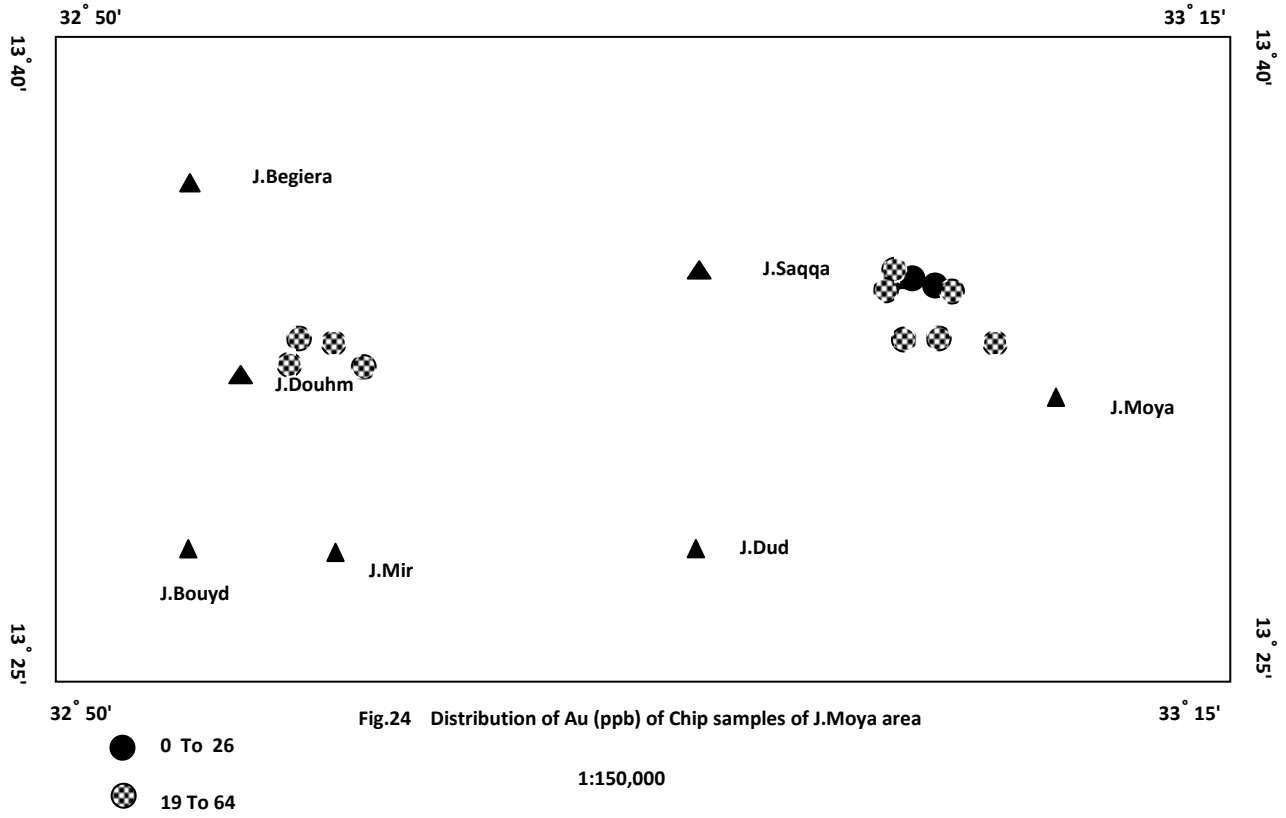


Fig.24 Distribution of Au (ppb) of Chip samples of J.Moya area

Discussion

As already mentioned the results of the orientational study indicate that size -63µ is the optimum size fraction for stream sediments geochemical survey in the study area. However, size -125µ may be good for a residual soil geochemical survey over anomalous areas. Such orientational study has not been conducted so far in the study area and the whole region of central Sudan. However parallel to this study similar work has been conducted in Qual- El-Nehal area of Eastern Sudan, a similar terrain regarding climatic conditions & topographic situation. The same results have been achieved (Ali, 2011).

CONCLUSIONS AND RECOMMENDATIONS

The results of the first phase of low density geochemical survey show some positive Au values and silver, copper, vanadium, zinc and iron0.

Chip samples have further confirmed the stream sediments samples study, showing high base metals (Zn & Ag) values and U & Th values. The base metals are related to gossanic features probably overlying volcanogenic massive sulfide deposits while U & Th anomalous values are closely related to granitic intrusion.

63µ is the best and optimum size fraction for any type of stream sediment geochemical survey in this region.

The area is very promising for base metals, gold and Th. Further investigations are recommended such as detailed exploration including bits , trenches and drilling.

More stream sediment samples will be collected over the study area using fraction -63µ size.

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