

# New Neo-Proterozoic Gold-Copper Gossan Discovery, EL Idaira Area, Red Sea Hills – Sudan

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**Abstract:** The study area is a part of the Nubian segment of the Arabian Nubian Shield (ANS) exposed in the Red Sea Hills of NE Sudan in which a new gold-copper gossanic occurrences is discovered southwest of Jebel Grain in AL Adara area. The ANS is dominated by low-grade juvenile arc terranes accreted to the Nile Craton to the west during the Neo-Proterozoic era (Greenwood et al., 1976; Vail, 1983). Volcanic-hosted massive sulphide (VMS) mineralization in the southwestern part of J. Grain located at EL Adara area was associated with hydrothermal episodes during breaks in a submarine intermediate to felsic eruptions activity within an Upper Proterozoic (900 Ma) tholeiitic to Calc-alkaline arc setting. Gold mineralization is found in the gossanic system (2.7 ppm), indicators for gossanic bodies are iron oxides, (Pyrite- FeS<sub>2</sub>, Chalcopyrite- CuFeS<sub>2</sub>). Gossan rock contains cavities left by leached out sulfide minerals. Boxwork masses are common. Average grade of CuO is (0.05 %), and 2.7 g/t gold. Average grade of 21 Samples for Iron Oxides is (11% Fe<sub>2</sub>O<sub>3</sub>), 38.5 ppm Zn, 0.02 % Pb, 0.019% Sb, 0.082% As. Arsenopyrite, malachite, Jarosite, silica-baritic Masses are the main mineral constituents in the enriched supergene oxidation profile. The massive sulphites were associated accessory calcite grains. Dacite occur by rock as low outcrops aligned along N-S shearing. Turbidities are exposed around the gossanic area. The main rock units hosting gossan are Tuffs, sheared and massive Andesite intercalated with chert, Metasediments such as quartzite, metavolcanic rocks and argillaceous rocks. Gold values in EL Adara area were positively related to both silica baritic rocks and pre-kinematic quartz veins. Massive dark brown to black color Patches or halos were shown around gold-bearing shear zones. The erd halos are believed to be formed by the leaching of pyrite. Both pyrite and chalcopyrite contain gold. Gossanic rocks that form over massive sulfide deposit were can be sizable in area. The first body is about 41931 m<sup>2</sup>, second body is 31008m<sup>2</sup>. Stream courses that drain the gossaneous ridges in the Study area host placer gold where there is an active artisanal gold mining take place.

**Keywords:** New Neo-Proterozoic Gold-Copper Gossan Discovery, EL Idaira Area, Red Sea Hills – Sudan

## 1. Introduction

The geochemical procedure of sampling protocol, and sampling of trenches was collected over a specified interval. In addition, channel samples were collected from quartz veins across strike, alteration zone within the host rock formation was channel sampled from the bottom on the floor trenches. More detailed sampling was made from mineralization zones.

All the Samples prepared were analyzed for gold at the Laboratory. Samples were decomposed by treatment with aqua regia (3HCl: 1HNO<sub>3</sub>). The gold is determined by aspirating the organic phase in the Atomic Absorption Spectrometry unit (AAS, novAA300). Selected trench and core samples were passed through X-ray Fluorescence (XRF) Spectrometry for trace elements determination.

The study area is a part of the Arabian Nubian Shield, it is good Model example to conducts the systematic geological mapping for Whole Study Area and attempt to understanding the genetically origin of the gold deposits in detailed exploration for this part of Arabian Nubian Shield, lithology and structure to understand the tectonic activity of the area which directed the following explorational stage. Systematic collection and analysis of samples will assist to produce a geochemical map of the Mineralization of quartz vein and alteration zone (Argillization), gossanic rocks.

The study area geologically comprise volcano-sedimentary such as andesitic-tuffs, sheared and massive andesite intercalated with chert, metasediments rocks such as quartzite, metavolcanic rocks argillaceous rocks. Intrusive dacite rock occurred as low outcrops with generally shearing strike 360 N-S and turbidities (volcano sedimentary rocks) exposure around the gossanic area.

Average grade of twenty one samples of iron oxides average (11% Fe<sub>2</sub>O<sub>3</sub>) with (7% Fe) and (76917.5 ppm Fe). Average concentration of values of Zn is 38.5 ppm, Average concentration values 0.094 % BaO with (324 ppm Ba). Average con. Of values (0.063 %) As<sub>2</sub>O<sub>3</sub>; (0.082 % As); (815 ppm As), 0.109048PbO%, (0.020%) Pb, (Av. of Pb = 204.8 ppm). Average con. Value of (Sb<sub>2</sub>O<sub>3</sub> = 0.019%), average concentration value 0.0017 % Bi<sub>2</sub>O<sub>3</sub>= arsenopyrote, malachite, Jarosite, silica baritic rocks formed in their enriched supergene oxidation profile. The massive sulphites have been associated with accessories of calcite grains base on chemical analysis results with average concentration value 0.35% of CaO.

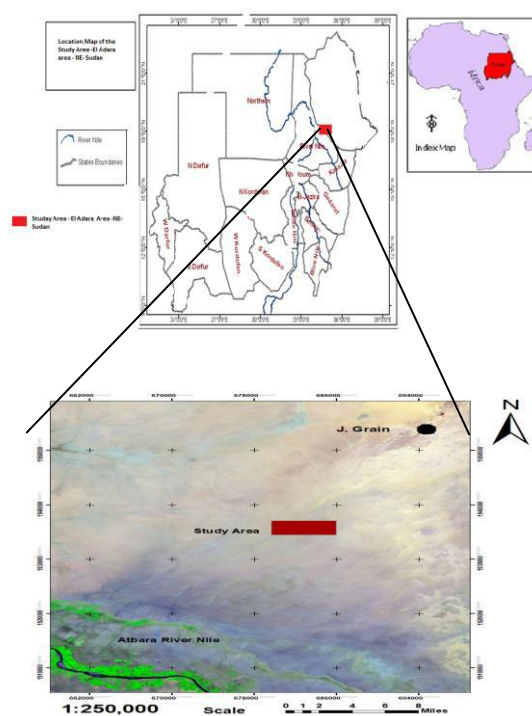


Fig. 1: Location map of new gossanic rocks in SW J. Grain- River Nile State

Fig. 1: Location map of the study area.

## 2. Regional Geology of the study Area:

In the study area amphibolites facies rocks represent windows of older, higher grade basement rocks beneath the stratiform layered sequences and thus were considered to be the sites of the stratigraphic units in study area. Amphibolite facies rocks represent in local areas of greater heat flow





Strike of Shearing to the N-S



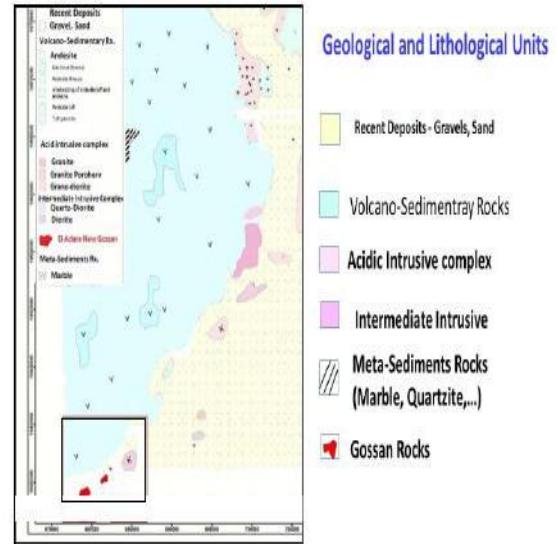
Strike slip fault to the NE-SW, N-S

**2.3 Detail Geology El Adara Area:**

The main lithological Units consist El Adara Area are; Meta-Sediments Rocks, Intermediate and Acidic intrusives, Granite, Gabro, Quartz veins clearly appeared during the open pit and trenches. Quartz veins mineralized, seems reddish to brownish to dark in colour similar chert. Some of them are ve

Vocnosedimentary Rocks and Recent Deposits.

**Geology of Study Area (El Adara Area):**



**3. Gold Mineralization in the study area:**

**3.1: Gold in quartz vein:**

Most of the quartz veins which occur in the north eastern part of the study area and in the central part and north J.Grain, vary in colour from whitish, brown and gold clearly appeared as nugget gold grains indiscontieous widespread areas of open pits, quartz veins are mineralized bearing gold-As, Fe, Zn, Cu. and have trend towards N-S, NE –SW these veins are intruded in sheared andesitic and intermediate meta-volcanic. Generally quartz veins vary from 2 meters up to 4meters in width (samples R12, R13) and are discontinuous veins.

In south western part of the investigation area, it is occurs many quartz veins with sulphides rocks and nugget gold may be remobilized after tectonic in fractured zone, cconjugate or cross brecciated Plate 2: Handsapciment of Nuget gold in quartz vein.

### Nugget gold in quartz veins in the Study Area



ins intercalated with gossanic rocks, Some of them



are veinlets, parallel and perpendicular to the general strike due NE.

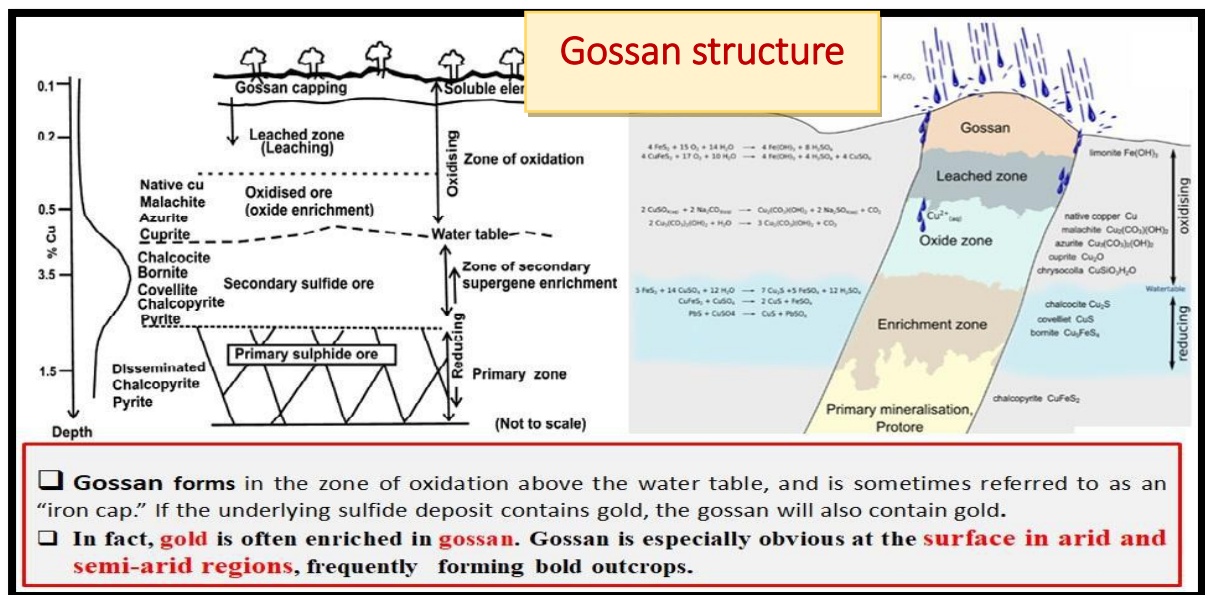
### 3.2:Diffinition and Strucure of Gossan:

It gets its name from a Cornish miner's slang "gōs", meaning "blood".

Gossan is defined as being an iron-bearing capping over a sulfide deposit. It is formed by the oxidation and leaching of sulfide minerals, leaving hydrated iron oxides such as limonite and goethite, along with magnetite see that with general View in (Fig.2 and Fig.3). Hematite and jasper may also form. It forms in the zone of oxidation above the water table, and is sometimes referred to as an "iron hat." If the underlying sulfide deposit contains gold, the gossan will also contain gold. In fact, gold is often enriched in gossan. Gossan is especially obvious at the surface in arid and semi-arid regions, often forming bold outcrops or "iron blowouts."

Many obvious gossans in the World have been examined more than once by prospectors. Since assay work can be expensive, many prospectors crush fragments of gossan and pan them in a small pan or dish, using only a small amount of water. If there are any gold colors at all, the prospector will pursue it accordingly.

Often, a gossan contains cavities left by sulfide minerals that have been leached. Cubic and triangular cavities usually indicate the former presence of sulfide minerals. There may be box-work or cellular masses, and there could be enrichments at depth. However, large cubic or triangular cavities in gossan could be a bad sign, because gold-bearing sulfides usually form as small crystals that would not create large cavities. Gossan is commonly found in areas where there are copper-gold ore bodies. There may be enough gold in gossan to form placer gold deposits in stream courses, below the outcrops. The presence of unaltered pyrite, chalcopyrite, or other sulfides in gossan is a bad sign, because it indicates that leaching is incomplete, and that enrichments. On the other hand, the presence of visible gold would be cause for rejoicing.



Color is another potentially useful characteristic, if used with caution. Massive dark brown to black gossan, sometimes iridescent, is formed by the leaching of pyrite. Reddish gossan may indicate the former presence of chalcocyanite. Both pyrite and chalcocyanite

can contain gold. Other colors may indicate the possible presence of molybdenite at depth. Color is not always reliable and should be used with care.

Gossan that forms over a porphyry copper deposit, or a massive sulfide deposit, can be sizable in area. Streamcourses that drain such areas may contain placer gold.

**3.2.1: Gold in Gossan in El Idaira Area - SW J. Grain:**

**3.2.1.1: Tectonic and Structural Feature of El Idaira Gossan:**

Gossanic rocks in this area forms over a massive sulfide deposit, can be sizable in area, first ore

body reached to about 41931m<sup>2</sup>, second is 31008m<sup>2</sup> extremely, and stream courses drain in surrounded areas contain placer gold. The average concentrations value of gold element it is 2.7 ppm, minimum value of gossanic rocks about 0.056 ppm and maximum values 13.76 ppm. (Table No.1) below.

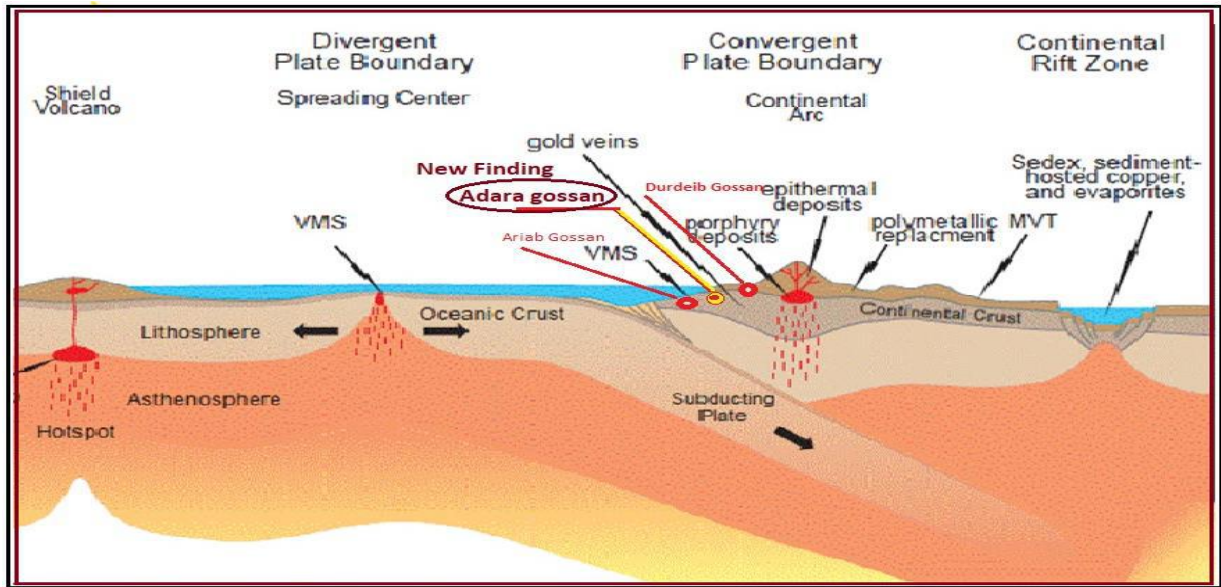


Fig. 4: El Idaira Gossan is exposures at the surface outcrop due to the fore arc plate movement to Subduction zone. Within the Convergent Plate Boundary and built up the Continental Arc during the Orogeny which is rich with Gold and Copper (VMS) and polymetallic replacement (Pb, Zn, S, Co, Ni,...)

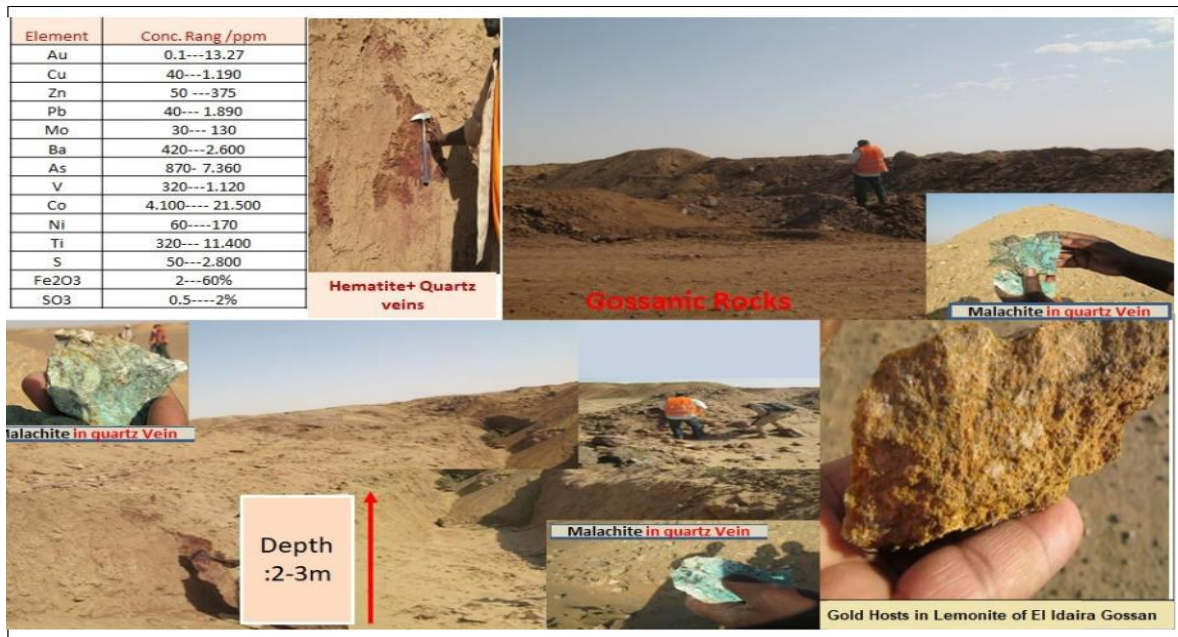
### Gold and associated elements in El idaira Gossan

Table No. 1: Chemical analysis results of 21 Chip samples of Gossanic rocks from surface and subsurface trenches and open pits from south western part of J. Grain

Hand Specimen Sample-1	Hand Specimen Sample-2
<p>Au = 4.389 ppm, Cu = 0.1 %, Zn = 25ppm, Mo= 128.5ppm, V = 322.5 ppm</p>	<p>Au = 13.766 ppm, Cu = 1.2 %, Zn = 375 ppm, Pb = 118 ppm, V= 1111 ppm, As= 7361 ppm, Ba= 413.4 ppm</p>

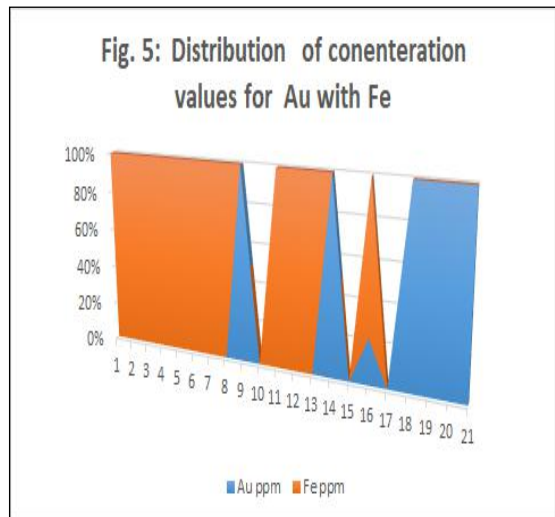
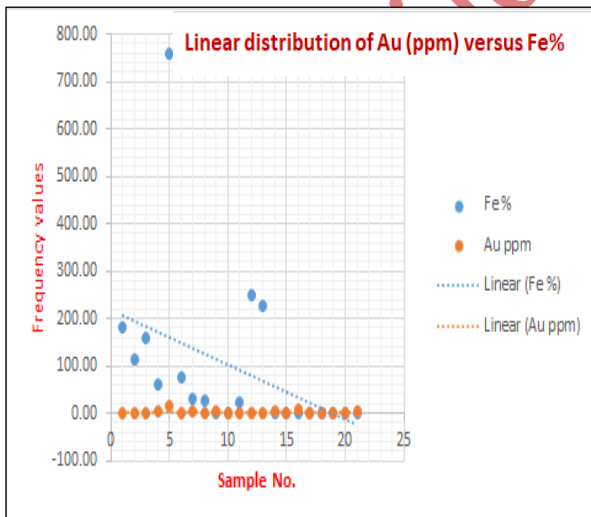
area.

	Sample No.	Samples description	Au ppm
1	R14D	Gossanic Rock	13.76
2	R43B	Gossanic Rock-H.R. Tuffes R. andesites	1.09
3	R14	SPR Silica pyritie (	4.04
4	R43A	Gossanic Rock	0.05
5	R14	criteria for indicators Gossanic rocks generally strike is N-S	12.09
6	Go.T2.	Gosanic Rocks	3.27
7	R13	Q.V. with nuget gold	4.38
8	R13GR	Hematite + quartz vein	0.03
9	R43B	Gossanic Rock - H.R. Tuffes R. andesites	1.09
10	R43A	Gossanic Rock	0.05
11	R43C	Gossanic Rock ( hematite)	6.44
12	R14BF	SPR Silica pyritie	3.22
13	R14A	Quartz veins	0.24
14	9G5	Gossanic rocks + q.v.	1.5
15	10G5	Gossanic Rock	1.77
16	2A	Gossanic Rock	0.17
17	17. R70	Gossanic Rock	0
18	R33G	Q.V. in gossanic rocks +malchite	0
19	R33	Q.V. in gossanic rocks +malchite	3.9
20	R14 .	- SPR Silica Pyrite	0
21	R14F	Gossanic rocks-Hematie	0
<b>Average</b>			<b>2.7</b>

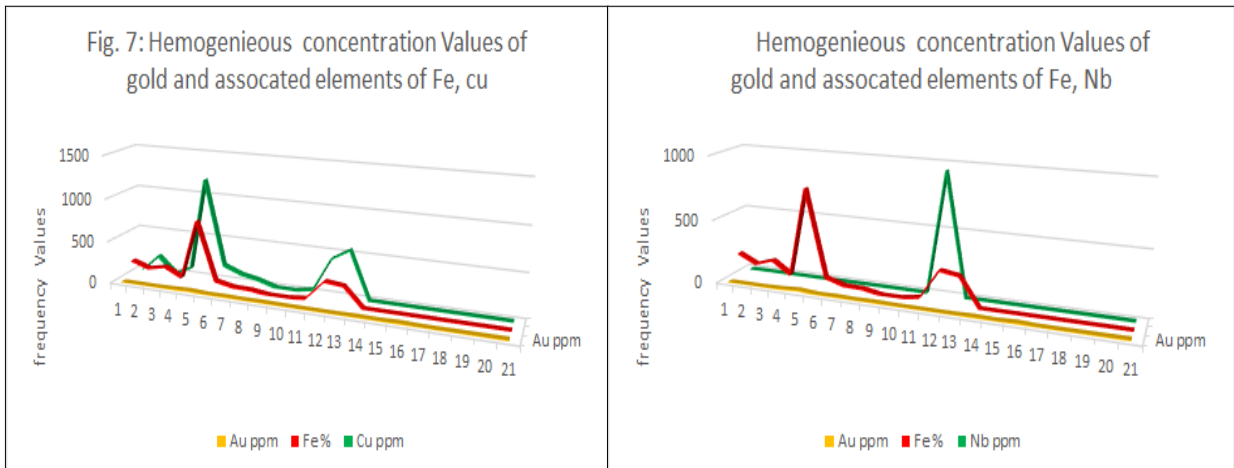


Plates : illustrated location and Hand spacements of Iron ore, Gossanic Rocks such as Hematite,

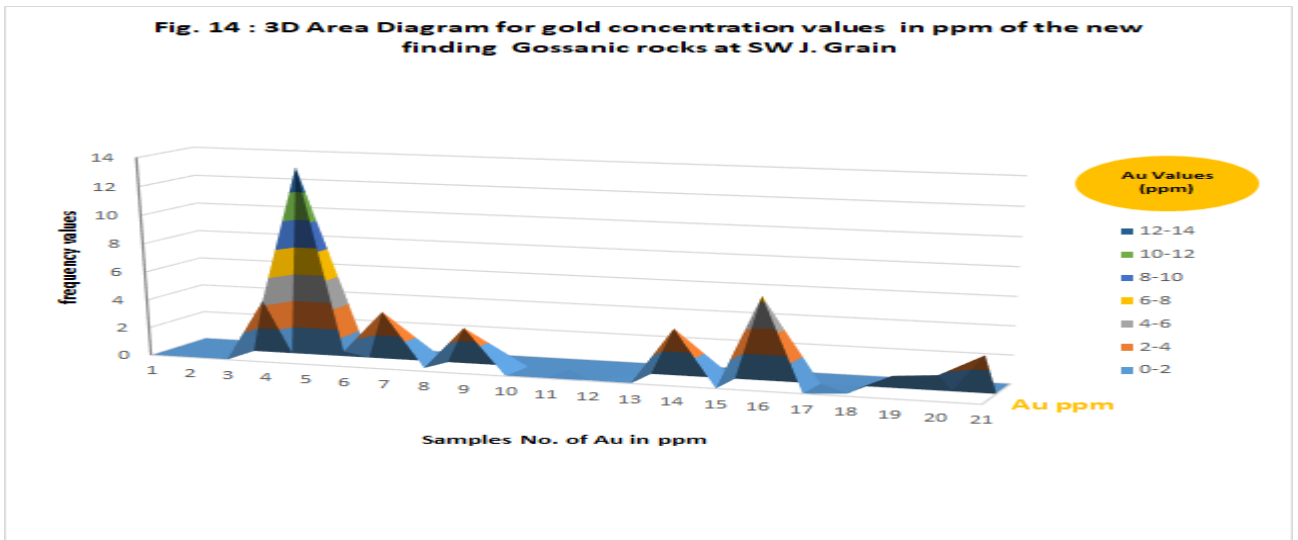
Distribution of Gold versus iron element (Fe)



Distribution of Gold and associated elements Fe, Cu, Nb



Distribution of Gold associated elements As, Ba.



Correlation Matrix is an assessment of the degree of relationship between two variables measured on a number of individuals.

The values of Correlation coefficient range between -1 and +1. A poor Correlation between element pairs is indicated by a Correlation coefficient close or equal to 0 while good Correlation is either positive or negative, are indicated by numbers approaching +1.0 or -1.0 respectively.

The correlation of gold and trace elements has shown positive correlation between gold and, Zn, and As and moderate positive correlation with Cu. While a negative correlation between gold and Mo, Co and Sb.

The correlation of sulfur and trace elements has shown strong positive correlation between S and Ti, Ba and positive moderate correlation between S and Zn and As, and show positive correlation with Cu, pb, Au and Mo. While a negative correlation between sulfur and Co.

### Correlation of Gold and associated elements

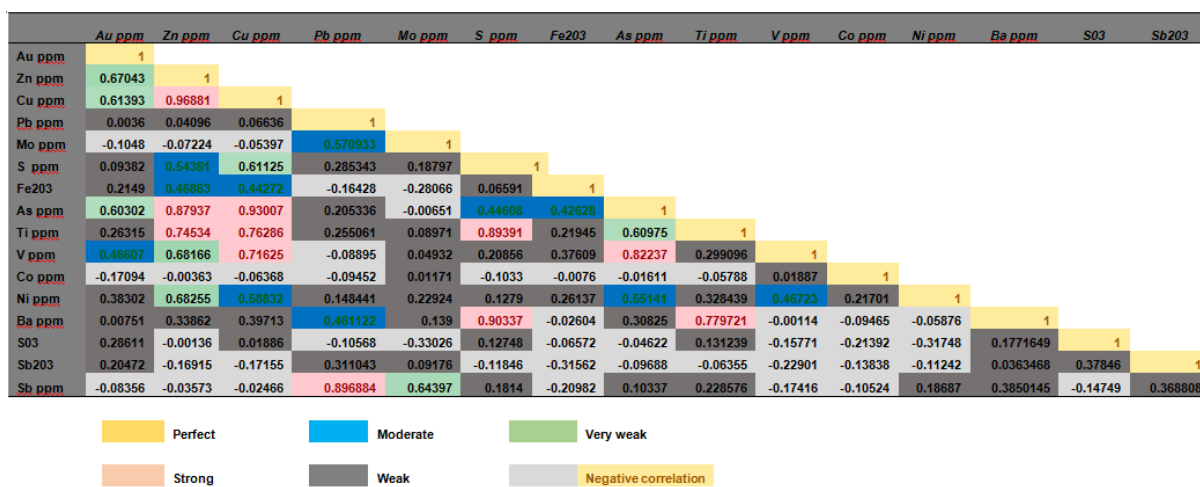


Table for Chemical Analysis Results of El Idaira area – Adarama Sheet , NE sudan

Sample no.	Sa. Na.	Field description	Au ppm	Zn ppm	Cu ppm	Pb ppm	Mo ppm	S ppm	Fe203	As ppm	Ti ppm	V ppm	Co ppm	Ni ppm	Ba ppm	S03	Sb203	Sb ppm
1	R12	ferrignated Q.V. within gossanic rock	0.0	41.7	0	0	43	252	10.9	0.0	551	573.5	0	76	0	0.063	0	0
2	R12B	Quartz iron oxide rock	0.0	33.3	192	0	43	528	6.8	0.0	0	0.0	0	76	0	0.132	0	0
3	R12C	Q.V. chert	0.0	33.3	0	0	29	52	9.6	0.0	755	0.0	21500	76	0	0.013	0	0
4	R13	Q.V. in gossanic rocks	4.4	25.0	96	0	129	640	3.7	0.0	1224	322.6	0	0	0	0.16	0	0
5	R14D	Gossanic Rock	13.8	375.0	1184	118	0	988	45.5	7361.5	7184	1111.1	0	165	413	0.247	0	0
6	R43B	Gossanic Rock - H.R. Tuffes R. andesites	1.1	50.0	184	1891	100	728	4.5	1767.8	3878	0.0	0	63	637	0.182	0.056	11200
7	R14	SPR Silica pyrite	4.0	25.0	104	1318	57	1304	1.9	1187.3	2082	0.0	0	0	2011	0.326	0.035	7000
8	R14A	Q.V. O.p.A	0.2	16.7	64	755	100	356	1.7	870.7	3102	0.0	0	63	693	0.089	0.059	11800
9	R14BF	SPR Silica pyrite - O.P.A	3.2	0.0	0	0	0	0	7.3	0.0	0	0.0	0	0	0	1.213	0	0
10	R14F	Gossanic Rock	0.0	0.0	0	0	0	0	60.0	0.0	0	0.0	0	0	0	0.24	0	0
11	R14	Ferrignated rock	0.0	0.0	40	0	43	412	1.4	0.0	327	0.0	0	63	0	0.103	0	0
12	R43A	Gossanic Rock	0.1	58.3	424	182	29	744	15.0	4353.6	1776	1039.4	4166	0	503	0.186	0	0
13	R14	Gossanic rocks	0.0	150.0	552	36	0	2792	13.5	1583.1	11388	0.0	0	0	2547	0.698	0	0
14	R33	Q.V. in gossanic rocks+ malchite	4.0	0.0	0	0	0	0	1.7	0.0	0	0.0	0	0	0	0.061	0	0
15	R33G	Q.V. in gossanic rocks +malchite	0.0	0.0	0	0	0	0	0.6	0.0	0	0.0	0	0	0	0.023	0	0
16	R43C	Gossanic Rock ( hematite)	6.4	0.0	0	0	0	0	0.0	0.0	0	0.0	0	0	0	1.053	0.149	0
17	R70	Gossanic Rock	0.0	0.0	0	0	0	0	31.5	0.0	0	0.0	0	0	0	0.204	0	0
18	2A	Gossanic Rock	0.2	0.0	0	0	0	0	6.7	0.0	0	0.0	0	0	0	0.197	0	0
19	9G5	Gossanic rock	1.6	0.0	0	0	0	0	3.3	0.0	0	0.0	0	0	0	0.285	0.051	0
20	10G5	Gossanic Rock	1.8	0.0	0	0	0	0	1.2	0.0	0	0.0	0	0	0	0.198	0.046	0
21	Q.V.	Gossanic Rocks	3.3	0.0	0	0	0	0	2.5	0.0	0	0.0	0	0	0	0.539	0	0

	Au	S	Fe	Zn	Y	Cu	Nb	Ba	Ce	V	As	Sb	Mn	Pb
Au	1.0													
S	0.1	1.0												
Fe	0.2	0.1	1.0											
Zn	0.61 (**)	0.59 (**)	0.45 (*)	1.0										
Y	0.48 (*)	0.2	0.3	0.55 (**)	1.0									
Cu	0.60 (**)	0.62 (**)	0.49 (*)	0.97 (**)	0.64 (**)	1.0								
Nb	-0.1	0.1	0.1	0.1	-0.1	0.2	1.0							
Ba	0.0	0.90 (**)	0.0	0.4	-0.1	0.4	0.1	1.0						
Ce	-0.1	0.1	0.1	0.1	-0.1	0.2	1.0	0.1	1.0					
V	0.46 (*)	0.2	0.4	0.65 (**)	0.4	0.68 (**)	0.58 (**)	0.0	0.58 (**)	1.0				
As	0.59 (**)	0.44 (*)	0.4	0.90 (**)	0.51 (*)	0.91 (**)	0.44 (*)	0.3	0.44 (*)	0.81 (**)	1.0			
Sb	-0.1	0.2	-0.2	0.0	-0.1	0.0	-0.1	0.4	-0.1	-0.2	0.1	1.0		
Mn	0.1	0.1	0.2	0.4	0.47 (*)	0.4	0.1	0.0	0.1	0.4	0.4	-0.1	1.0	
Pb	0.0	0.3	-0.2	0.1	-0.1	0.1	0.0	0.44 (*)	0.0	-0.1	0.2	0.90 (**)	-0.1	1

**References:**

**4. Conclusion**

- ❑ El Adara area is dominated by metavolcanic rocks represented by andesitic tuff, sheared and massive andesites intercalated with Chert, Metasediments rocks such as quartzite, argillaceous rocks. Intrusive dacite rock occurred as low outcrops with generally N-S shearing and Turbidities exposure around the gossanic area.
- ❑ Gold mineralization is found in the gossanic system (2.7 ppm), indicators for El Idaira gossanic bodies are iron oxides, (Pyrite,Chalcopyrite). Gossan rock contains numerous vugs of leached sulfide minerals. Showing boxwork and cellular masses. There could be enrichments at depth. Average grade of CuO is 0.05 %, and 2.7 g/t gold.
- ❑ Average grade of positive Samples for Iron Oxides is (11% Fe2O3), 80 ppm Zn, 853 ppm Pb, 10,000 ppm Sb, 3000) ppm As.
- ❑ Gossanic rocks that form over massive sulfide deposit are sizable area.

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- ❑ The local drainage system of El Adara hosts placer gold.