

An approach for the economic potential Of gold in the umm gheig district, Egypt

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Abstract

The present study deals with the economic potential of gold occurring in the bed rocks and mineralized zones at Umm-Gheig district as well as the resource calculation of Kab- Moussa placer gold, Eastern Desert, Egypt. The experimental techniques of the amenability of gold extraction using cyanide carbon in pulp (C.I.P) leach technique, are carried on eight representative composite samples of the bed rocks and mineralized zones cropping out at the different localities in the district. High recovery of gold extraction is recorded at the areas of Kab-Moussa, Khor Abu-Merewa, and Hamrat Ghannam. Moderate gold recovery is recorded at Gabal Nusla, and Wadi El-El-Sherm El-Bahari. The least recovery is recorded in the banded iron ore at Umm Shaddad area. Using both the arithmetic (\bar{X}) and geometric means (π) the calculated resource of placer gold at Kab -Moussa area are 1.260 ton and 1.208 ton respectively.

Keywords: Umm Gheig District, Gold, Extraction, Recovery

1. Introduction

The present study deals with the economic potential of gold in the stream sediments and source Pan African rock types cropping out at Umm- Gheig district. This district is a part of the Central tectonic domain of the Eastern Desert. This district includes W.Umm-Gheig, Kab-Moussa, W. El El-Sherm El- Bahari, Khor Abu-Merewa, Khor Abu- Harida, and Gabal Hamrat Ghannam as well as Gabal Nusla where abnormal gold contents were recorded (Sakr, 2006 and Hassaan et al, 2009). The district is located from Wadi Umm Gheig in the South to Wadi Hamrat Ghannam in the North between latitudes $25^{\circ} 30' 00''$ N and $25^{\circ} 50' 00''$ N, and longitudes $34^{\circ} 15' 00''$ E and $34^{\circ} 25' 40''$ E. Abu El Leil, et al, (2015) recorded in the mineralized zones, host and country rocks exposed at the studied localities located in Umm-Gheig district the following ranges of gold content (g/t): Kab-Moussa (1.06-0.16), Kab El-Rokab (1.0-0.24), Gabal Nusla (1.2-0.2), Khor Abu-Merewa (61.62-0.25), Wadi El-Sherm El-Bahari (2.0-0.18) and Hamrat Ghannam (14.54-0.18) (Fig.1) These ranges of gold encouraged to collect eight composite samples represent the rock units and mineralized zones bearing gold at each locality to be fire assayed to carry out experimental work on gold extraction. Moreover the detailed fire assayed gold contents in the alluvial sediments filling Kab-Moussa area recorded alluvial placer gold (Abu El- Leil et al, op. cite). The average contents in the grain size classes less than 2 mm are calculated using the 32 fire assay gold analyses of Abu El Leil et al, (op. cit.). The present work aims at undertaking gold extraction experiments on the these eight representative composite samples as well as calculating the amount of gold in the recorded Kab-Moussa alluvial placer gold to reveal the gold economic potential of Umm-Gheig district.

1.1 Technical Experiments

Gold Resource comprises three major steps: extraction, beneficiation operations and processing. Extraction is analogous to mining and is defined as removing ore material from a deposit. Four main techniques to be used in the beneficiation of gold ore are cyanidation, flotation, amalgamation, and gravity concentration. The method that can be used varies with mining operations and depends on the characteristics of the ore and economic considerations. Therefore cyanidation will be applied for gold beneficiation technique in the present study. In general, there are two basic types of cyanidation, tank leaching and heap leaching. In addition, tank leaching involves one of two distinct types of operations, Carbon-in-Pulp or Carbon-in-Leach. The former is the applied technique in this study where, the ore pulp is leached in an initial set of tanks with carbon adsorption occurring in a second set of tanks. Flotation is a technique in which particles of a single mineral or group of minerals are made to adhere, by the addition of reagents, preferentially to air bubbles (U.S. EPA, Office of Water 1982). Gravity concentration techniques used most at placer mines rely on gravitational forces to suspend and transport gangue away from the heavier valuable mineral. Amalgamation operations, where metallic gold is wetted with mercury to form a solution of gold in mercury, referred to as an amalgam. Cyanidation is the predominant

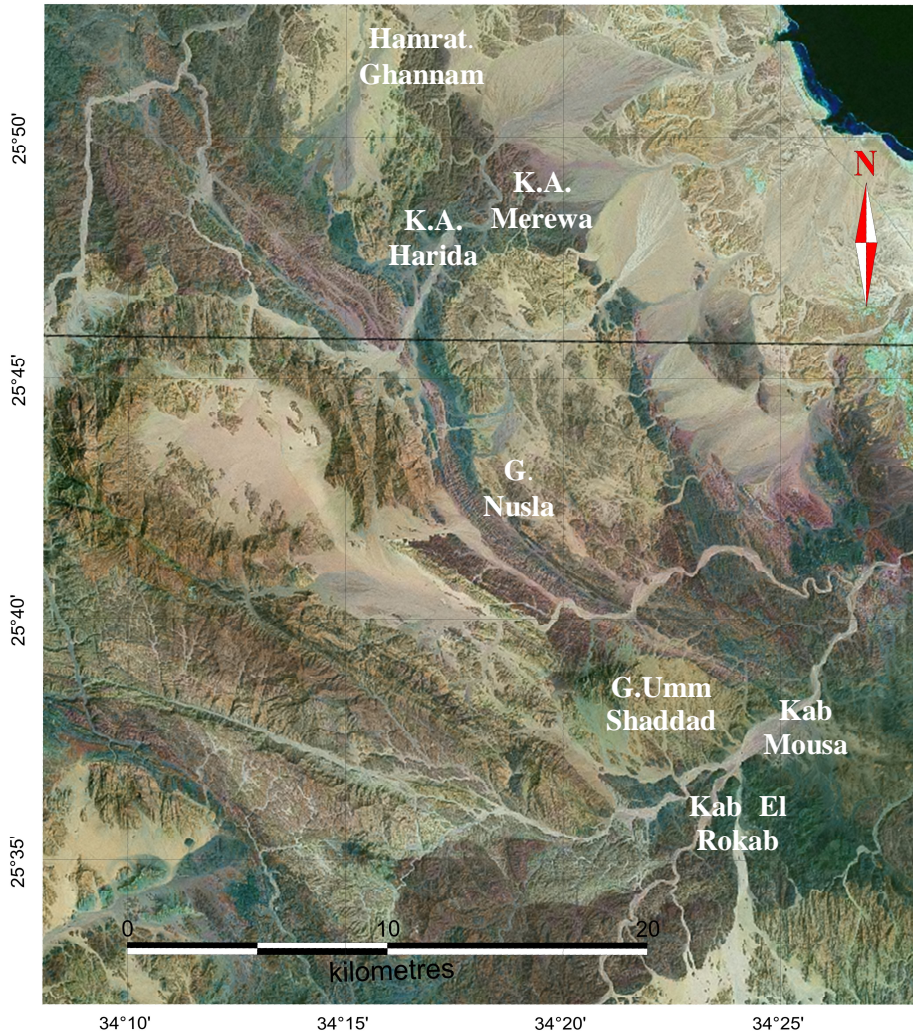


Fig. 1: Land Sat image showing Location of the studied localities

method used to beneficiate gold ore. This technique uses solutions of sodium or potassium cyanide as lixiviants (leaching agents) to extract precious metals from the ore. Cyanide heap leaching is a relatively inexpensive method of beneficiating low-grade gold ores while tank leaching is used for higher grade ore. The Na CN solution is used for tank leaching of gold bearing rock types. Cyanidation techniques include heap or valley fill leaching followed by carbon adsorption (carbon-in-column adsorption), agitation leaching followed by carbon-in-pulp (CIP), or agitated carbon-in-leach (CIL). The first technique is applied in the present study. Cyanidation is best suited to fine-grain gold in disseminated deposits. CIP and CIL techniques, commonly referred to as tank or vat methods, are generally used to beneficiate ores containing more than 0.04 oz/t. These gold beneficiation cut-off values are dependent on many factors, the most effective one is operation's ability to recover the gold. Cyanidation-carbon adsorption is considered in four steps: leaching, loading, elution, and recovery (van Zyl et.al, 1988). In leaching, the cyanide form a cyanide-gold complex in an aqueous solution. Gold values in solution are loaded onto activated carbon by adsorption. When the loading is complete, the values are eluted, or desorbed from the carbon, and recovered by electrowinning or zinc precipitation, prior to smelting. In the present work the loaded carbon was fire assayed to recover the gold. The advantages of cyanide leaching are:

- Only a relatively small amount of cyanide is needed to recover gold, usually less one kg of cyanide per tonne of rock.
 - Cyanide is very selective leaching gold and only minor amounts of other minerals in the ore.
 - Cyanide leaches coarse and very fine gold as well as gold that is attached to the rock.
 - The process is quick; tank leaching normally takes less than one day.
 - Cyanide remaining in the waste (tailings) product can be destroyed to minimize the environmental impact.
- The disadvantage of cyanide leaching is that cyanide is highly toxic

1.2 Gold Extraction

The gold ores can be classified according to the amenability of gold extraction into the following:-

Free-milling gold ores:-

These ores are defined as those from which cyanidation can extract approximately 95% of the gold when the ore is ground to a size of $80\% < 75\ \mu\text{m}$, as commonly applied in industrial practice, without incurring prohibitively high reagent consumption.

2- Non-refractory sulphidic gold ores:-

In such cases, the gold is not locked in the sulfides and is available for leaching, these ores may still yield acceptable gold recoveries $> 90\%$ by direct cyanidation.

3- Refractory sulphidic gold ores:-

These ores must be oxidized prior to cyanide leaching to achieve acceptable gold recovery.

1.3 Gold Liberation

As a general rule for concentrating minerals it is to be mentioned that to concentrate the mineral of interest the mass of the undesirable material representing the gangue minerals must be discarded, (Marcello, et al., 2006). In this respect when the gold is concentrated using gravity concentration a lot of fine grained gold will be lost. On the other hand, the main loss is usually in the coarse fraction of the tailings, because there is often gold that is not liberated in the coarse gangue that can be liberated, by grinding. This concept of “mineral liberation” is very important to communicate to extraction process. The liberation size of the gold, is the grain size which allows the gold to be free from the gangue silicate rock minerals to be exposed to leaching by cyanide. So, it is clear that the first step before grinding and concentrating gold is to determine the best grain size in which most of the gold will be liberated from the gangue. This primary process which required to liberate gold from gold-bearing minerals, and other metals of economic value to make them amenable to subsequent gold extraction steps is called comminution (John et al., 2006). The degree of comminution required depends on many factors, including the liberation size of gold, the size and nature of host minerals, and the method to be applied for gold recovery. The presence of iron sulphides form ferro-cyanide complexes, copper minerals are readily soluble in cyanide solutions causing the largest cyanide consumption. Arsenic and antimony minerals form cyanide complexes and reduce the dissolution rate. In some cases the naturally occurring of carbonaceous materials act as adsorbents for the gold dissolved by the cyanide solution Shaaban (1984). Organic compounds such as decayed wood, oil, grease, and floatation reagents slow down cyanidation of gold by consuming the dissolved oxygen.

The occurrence of gold as free, fine-size and clean particles accelerate the rate of dissolution, where under ideal conditions gold will dissolve at a rate of 3.36 microns per hour.

2. Gold Extraction by Agitation Method

A total of eight composite samples represent the area of study were prepared as representative samples by crushing and grinding in order to study their amenability to gold extraction using the cyanide leach technique. These samples were treated by agitation with 0.2% NaCN solution under the following conditions: Weight of sample -2kgs, grain size -50 μ , Solid liquid ratio -1:2, NaCN concentration - 0.2%, PH of solution - 10 – 11, and the duration of leaching is 48 hrs. The pulp was decanted, filtered and the pregnant solution was mixed with activated carbon for gold adsorption. The loaded carbon was removed and the gold was extracted by melting the carbon-silica charge in fire assay furnace. The results are recorded in (Table, 1)

2.1- Gold Extraction Results

From the gold extraction results by agitation technique (Table 1) the samples of Kab Musa, Wadi Kab El Rokab, Khor Abu Merewa (1,2), and Hamrat Ghannan area recorded high recovery of gold which due to the presence of gold as fine disseminated free particles accelerated the extraction rate. Meanwhile the samples of Gabal Nusla and Wadi El-Sherm El Bahari the recovery is moderate probably due to the presence of carbonate minerals, iron oxide and sulphides which slow down the rate of extraction. It may need ultrafine grinding to liberate the very small gold particles at Gabal Nusla (0.3 to 1.5 μm). Finally the least recovery is obtained from the sample of banded iron ore nearby Gabal Umm Shaddad due to the high percent of iron oxides and sulphides that impeded the gold extraction and affected the conditions of process operating.

$$\text{Recovery \%} = \frac{M_p}{A_{ut} \times M_t} \times 100$$

Where:-

A_{ut} = Gold assay of the head sample, g /t (or ppm).

M_t = Weight of sample by tonnes.

M_p = gold produced by grams.

Table, 1: Extracted Gold and Recovery % after Agitation of 2 Kg of Each Sample.

Ser. No	Sample No.	Area	Feed Grade g/t	Gold Recovered (mg.)	Recovery %
1	E-1	Kab Musa	0.50	0.912	91.2
2	E-2	Wadi kab El Rokab	0.70	1.276	91.1
3	E-3	Gabal Nusla	0.30	0.320	53.3
4	E-4	Khor Abu Merewa 1	1.72	2.724	79.1
5	E-5	Khor Abu Merewa 2	10.1	18.348	90.8
6	E-6	Wadi El-Sherm El Bahari	0.66	0.892	67.6
7	E-7	Hamrat Ghannam	1.14	2.176	95.4
8	55/1	BIF, Umm Shaddad	0.28	0.136	24.3

3. Kab Mousa Placer Gold

The recorded heavy ore minerals at Kab-Mousa are, magnetite, ilmenite, hematite, goethite, sphene, garnet and zircon. The ranges and averages of 32 analyses of heavy concentrates of the grain size fractions less than 2 mm by fire assay for gold and atomic absorption spectroscopy for silver and associated elements given in table, (2) point to the presence of promising silver-gold alluvial placer reaching up to 1.4 g/t and 1.05 g/t respectively (Abu El Leil et al 2015). Both metals are recorded in reasonable concentrations in an area of 4.2 square Km representing a placer silver-gold. The present part is going to calculate the gold resources in Kab- Moussa alluvial placer gold (Fig. 2).

Table, 2 : The ranges and averages of elements in 32 Alluvial Samples, Kab Mousa.

Elements	Range (ppm)	Average (ppm)
Au	1.05- 0.19	0.72
Ag	1.40-0.00	0.29
Cu	63-11	21.5
Pb	35-19	24.0
Zn	317-34	173.6
Co	70-28	43.0
Ni	36-9	16.2
Mo	93- 4	34

3.1 Amount of Sediments

- * The average thickness of the alluvial sediments at Kab- Moussa area equals 5m.
- * The amount of the bulk placer gold in the area equals 21.000000 million cubic meters.
- * The amount of the grain size less than 2 mm (represent about 65% according to the study) forming the placer gold equals 13.650000 million cubic meters.
- *Regarding to the specific gravity of the sediments to be about 2.5 gm/cm,³ the total weight of the bulk sediments of the placer gold equals 34,125000 million tons.
- *The heavy concentrate consists mainly of ore minerals (which represent 5.13% of the total grain size less than 2 mm) equals 1,750613 million tons.

3.2 The Expected Resources:-

- *Regarding to gold content given in table 4-1, the calculated arithmetic mean (\bar{X}) and geometric mean (π) the values of gold is 0.72 g/t and 0.69 g/t respectively.
- *The total weight of heavy concentrate bearing the gold = 34,125000(total weight of sediments less than 2 mm) multiplied by 5.13%(% of heavy concentrates) =1750613 ton
- *Total weight of gold (by using arithmetic mean (\bar{X})). = 1750613 × 0.72 =1260441 gm
- *Total weight of gold divided by 1000000= 1.260 ton
- *Total weight of gold using the geometric mean (π)). = 1750613 × 0.69 = 1207923 gm
- *Total weight of gold divided by 1000000= 1.208 ton

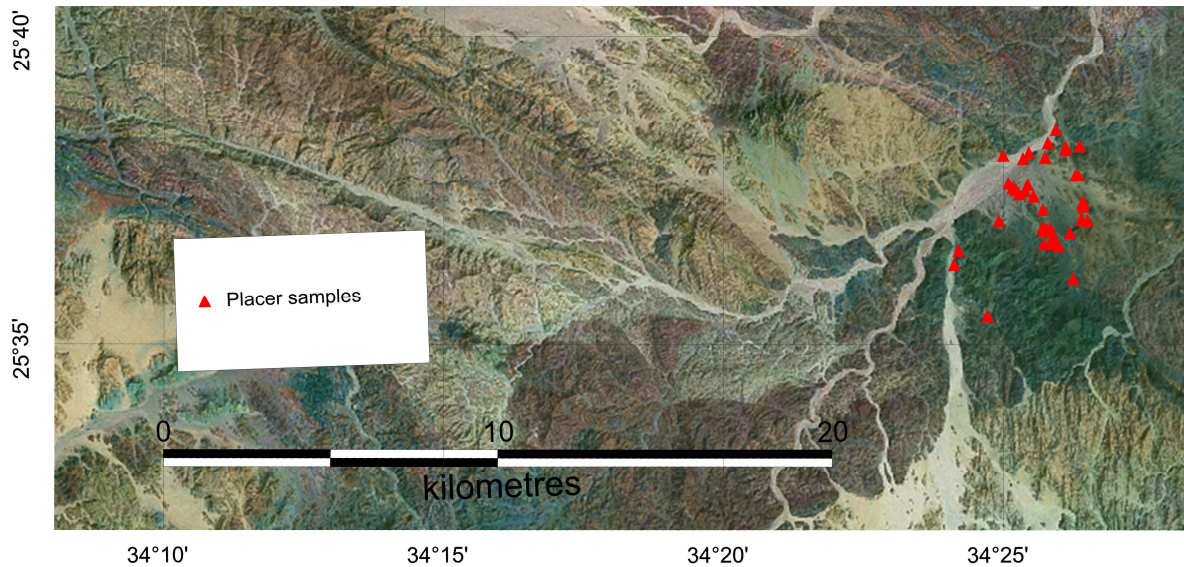


Fig. 2: Land Sat image showing stream sediment sampling sites, Kab Moussa area

4. Conclusion

Gold extraction of the mineralized zones and host bed rocks at Umm Gheig district using cyanide leach technique as well as the resources calculation of expected alluvial placer gold at Kab-Moussa area, Eastern Desert Egypt, revealed the following results.

1. High recovery of gold was obtained from the samples represent the areas of Kab-Moussa, Wadi Kab El Rokab, Khor Abu Merewa, and Hamrat Ghannam. The localities of Gabal Nusla, and Wadi El-Sherm El Bahari recorded moderate recovery of gold extraction. The recovery of gold of Umm Shaddad banded iron ore is low to be considered of economic potential.
2. The resource calculation using arithmetic (\bar{X}) and geometric (π) means of the alluvial placer gold at Kab-Moussa area is the grain size < 2 mm recording 1.260 ton, and 1.208 ton respectively.
3. Further detailed studies on the Umm Gheig district for gold investment are recommended.

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