A New Method for Recovering Fine Gold from Sands

Wael Zaghloul ElSayad

Abstract: ***The scarcity of gold in large quantities has led mining entities to turn to the exploitation of gold dust contained in refractory ores. However, the inadequacy of the various methods employed in the extraction of the gold dust often leads to unnecessary loss of the finest gold particles that are washed away by water or any other solution used in the process. The insatiable market demand for gold coupled with its scarcity, therefore, calls for improved methods to elevate the efficiency of extracting the gold dust. The froth flotation technique has, however, shown remarkable efficiency in the extraction of the fine gold particles contained in gold ores. The method uses a mixture of water and coil-oil that has naturally occurring ferrous sulfide which essentially acts as the surfactant. The improvement of the surface tension of water, the frothing produced by the coal-oil and the hydrophobicity nature of gold play an essential role in elevating the efficiency of the method in the extraction of gold dust.***

Index Terms: ***The extraction of gold dust, the hydrophobicity, the ferrous sulfide, surface tension, light weights, non-toxic..***

I. INTRODUCTION

The importance of gold to the world economy has elevated its status as a precious metal. The economic value of gold is, however, sustained by its scarcity, use in electronic devices and the universal agreement to make the metal the basis of every economy. The use of gold as a means of exchange has been in existence since time immemorial. However, as indicated above, the absence of gold in large quantities has led to the mining of gold dust that is often contained in black soils. The process of extracting gold from gold ores is an expensive and tedious undertaking that requires both patience and constant innovation to increase its efficiency. Samples of fine gold in sand have been highlighted in "**Fig. 1**"and "**Fig. 2**", displayed below.

Fig. 1. Fine gold in black sand concentrate.

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Fig. 2. Fine gold in sand.

There are various methods that are used to mine gold dust but very few have been successful in completely recovering all the gold dust contained in refractory ores. A majority of the methods employed in the extraction of gold dust essentially use water to separate the gold particles from the other materials.

However, though these methods are quite remarkable in extracting the gold particles, it has become completely impossible to extract the extremely fine particles of gold. The economic value of gold in the world market calls for the highest efficiency in the recovery of gold. Furthermore, the scarcity of the metal and the demand in the world market has necessitated the adoption of new methods and technologies that enhances the recoverability of the dust metal. Though the extraction of fine gold particles can be done with the assistance of other solutions and non-solution methods the use of water tend to be popular due to its high efficiency. One of the major challenges of using water as a separating medium is the inability to recover the extremely fine gold particles that are suspended in water. In essence, the microscopic gold particles are mostly washed away as waste.

Current methods employed in the extraction of gold dust however take advantage of the hydrophobicity nature of gold and the flexibility of surface tension of water to extract gold dusts contained in black soils. These methods use additives to increase the surface tension of water which essentially supports the weight of the gold dust on the surface. The method of froth flotation that makes use of coal-oil as the surfactant.

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In the exploitation of gold dusts from the black soils and other refractory ores has significantly impacted the gold mining industry. However, the efficacy of this method can be attributed to the presence ferrous sulfide in coal-oil that essentially improves the surface tension of water. Furthermore, the frothing that is generated by the coal-oil plays a significant role in the trapping of the gold dusts ejected from the gold ores. The advantages of the ferrous sulfide are that it is less toxic and improves both the surface tension of water and adhesive forces of the gold dust.

II. HYDROPHOBICITY OF GOLD

The unique floating characteristics exhibited by gold can, however, be manipulated to increase the productivity of mining fine gold contained in black soils [1]. However, a clear understanding of the reasons that make gold to float on the surface of water despite being four times heavier than water is necessary in the design of an optimal method that elevates the efficacy of gold extraction from the gold ores [1]. In retrospective, gold is considered hydrophobic which means that it repels water away from it. In essence, any gold suspended in water as long as it is lighter than the upward pull of the water [2]. However, to make the gold dust float on the surface of the water, interventionists mechanisms are required to increase the surface tension of the water [1].

III. FLUIDS SURFACE TENSION

The surface tension of water refers to the microscopic membrane that forms on the surface of water and it has the capability to support light weights [3]. The strength of the membrane is however affected by changes in temperature. In essence, surface tension weakens as temperatures increases beyond the room temperature. Furthermore, the membrane is affected by some types of chemicals which inhibit the weak bonds that join the water molecules together [3]. However, there exist some special types of additives, such as Ferrous Sulphide, that retrospectively are known to contribute to the strengthening the ability of the surface tension to support light weights.

IV. FROTH FLOTATION USING COAL-OIL AS A SOURCE OF FERROUS SULFIDE

The use of water as the solution of interest in mining of gold dust is preferred due to its availability and therefore, it is economical to employ in the large scale commercial mining of the gold dust. Furthermore, water does not react with gold as it would be expected with other solutions. Thus, the use of water would be more appropriate as it does not involve other costly processes such as washing away of chemicals. In essence, the use of water in commercial extraction of gold dust makes more economic sense than any other solution. However, it would be appropriate to understand how ferrous sulfide and other additives contribute to the increment of the water surface tension. Water molecules are essentially bound together by the Van der Waals forces. These forces are usually weak and have a polarity which acts as the glue that attaches the water molecules together.

The use of the ferrous sulfide, which occurs naturally in coal-oil, essentially increases the strength of the Van der Waals forces and ultimately the surface tension of water is improved [4]. The improved surface tension of water is essential for supporting the floating capability of the light weights such as the gold dust [4]. The elevation of the surface tension of water allows any light weights to float on the surface of the water rather than suspend inside the water. The effects of the ferrous sulfide on the surface tension of water assist in providing a solution to the previous challenge where gold dust was easily washed away unnoticed. The application of the ferrous sulfide in the elevation of the surface tension of water allows the floating gold dust to be easily scoped which is an action that would be difficult to achieve with the low values of surface tension [4].

Furthermore, ferrous sulfide is much less toxic compared to both mercury and cyanide that are employed in the commercial extraction of gold [7]. The use of mercury and cyanide, though effective in the extraction of gold due to their unique characteristics, has been considered to be harmful to the environment and the miners alike. Mercury is categorized as a heavy metal and is known to be a major cause of various types of cancers. On the other hand, cyanide is a harmful chemical that can lead to instant death if improperly handled.

V. CHEMICAL ANALYSIS OF FERROUS SULFIDE

The analysis of the chemical composition of the ferrous sulfide and how it reacts with water is essential as it provides a glimpse on how the commercial handling of the additive can be carried out without contributing to the deterioration of the environment. Ferrous sulfide is essentially composed of both iron and sulfur and is obtained by heating the two elements together. However, the compound also occurs naturally alongside other minerals such as coal and in refractory ores. Ferrous sulfide is a soluble agent that dissociates into ferrite ions and sulfate molecules in water. The dissociation of the ferrous sulfide into charged molecules is responsible for the strengthening of the Van der Waals forces that bind the water molecules together. It is worth noting that the ferrous sulfide contained in the coal-oil is a stable compound and only decomposes to its constituent molecules when introduced into the water.

One of the major advantages of the ferrous sulfide is that it does not release harmful chemicals into the environment as compared to mercury and cyanide. In essence, the use of the ferrous sulfide can be employed as an alternative to cyanide and mercury in commercial extraction of gold dust. However, though the ferrous sulfide is non-toxic to the environment, sulfur generates other toxic chemicals when burnt in open air. Therefore, it is essential to ensure the chemical is properly handled to avoid contaminating the environment. Furthermore, the management of the solution that is formed after ferrous sulfide is added to pure water is important to avoid contaminating sources of pure water around the gold mines.

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VI. COMMERCIAL APPLICATION OF FERROUS SULFIDE IN GOLD EXTRACTION

Several methods exist that manipulates the surface tension of water to extract gold dust contained in black soils [4]. The use of coal-oil as a source of ferrous sulfide is continuing to take roots in the mining of gold dusts due to its significant as an additive for raising the surface tension of water. The mixture of water and gold bearing materials are then agitated to form a froth that traps gold dust [5]. The analysis of the above process indicates that the process is made possible by both the viscosity and surface tension of the solution formed [5]. However, the increment of the surface tension, as shown before, is made possible by the traces of the ferrous sulfide present in the coal-oil. The commercial utilization of this process is done through the process of froth flotation [1]. Though a majority of these methods do not apply ferrous sulfide as an additive for raising the surface tension of water, the agents that are employed contain traces of the ferrous sulfide. However, the use of coil-oil is becoming more popular due to its high content of ferrous sulfide and the frothing effect it generates. In general, froth floatation is a technique that easily separates hydrophobic materials such as gold from hydrophilic materials [1]. The hydrophobicity of gold and the ability of ferrous sulfide to increase the surface tension of water create an opportunity for an efficient method for the extraction of gold dust [1].

The implementation of this process involves the grinding of the refractory gold ore into fine and soft particles [1]. Common industrial practices dictate the grinding of the gold ore material to sizes below 100 micrometers. The ground ore is then mixed with fresh water and coal-oil is gradually added to the mixture to increase the surface tension of the water [1]. The light weight of the ground particles coupled with the increased hydrophobicity of gold makes the gold particles or dust to float on the surface of the water [1].

Several key factors, however, dictate the efficiency of this method. First, care should be taken to regulate the temperature of the water which is inversely proportional to the strength of the surface tension [6]. In essence, an increase in temperature leads to an automatic decrease in the strength of the surface tension. Furthermore, low temperatures essentially lead to the hardening of the coal-oil [6]. The industrial rule of thumb is to maintain the temperature of the solution at temperatures slightly above the room temperature. The surface area under which gold particles come into contact with the mixture of oil and water is another factor that contributes to the improvement of efficiency of gold extraction using this method [6].

The grinding of the gold ore into extremely fine particles increases the surface area of the gold particles [2]. It is worth noting that the surface area of an object increases as its volume decreases. In essence, the ground gold particles have a higher effective hydrophobicity on account of their small sizes compared to those with large sizes [2]. In other words, finely ground gold particles have a higher hydrophobicity compared to those that are relatively ground [6]. Again, the efficacy of the method is improved by spreading the ground gold ore so that their depth from the bottom of the holding container is within a range of a few millimeters. The significant of spreading the ground gold ore is to increase the surface area [6]. The increased surface area allows all gold particles to have adequate space for interacting with the water which leads to increased hydrophobicity [6].

Furthermore, in tandem with the frothing techniques employed in gold extraction, the agitation of the mixture allows all gold particles to have a direct contact with water and to escape from the entrapment of other materials [6]. The stirring process should, however, be done continuously for some time and then stopped to allow the gold particles to rise to the surface of the water. The extraction of the gold particles is however made possible by the unique property of ferrous sulfide that improves the cohesion properties of articles of the same nature [6]. Therefore, the gold dust and particles tend to form around each other which make their scoping easy.

The efficacy of the method can also be improved through two other important methods. First, the flotation cell or tank is filled with the water to ensure that other lighter particles cannot float on the surface of the water [6]. Again, the injection of the air bubbles at the bottom of the floatation cell increases the hydrophobicity of gold particles which escape into the air bubbles. The air bubbles then provide an easy mechanism for the gold dust to reach the surface of the water [1]. The main benefit for this method is that it allows gold mining companies to extract high-quality gold from low-grade ores which is a practice that is not possible with any other method [1].

VII. CONCLUSION

The economic value of gold in the international market has effectively contributed to increased innovative methods for its extraction. The scarcity of gold nuggets has led individual miners and companies alike to result in the extraction of gold dust from gold ores such as the black soils. However, the available methods for extracting gold are inadequate because they are not able to extract the extremely fine gold particles from the gold ores. Methods that use solutions such as water to extract gold particles, though effective hardly collect all the gold as some of the gold dust is washed away.

However, the exploitation of both the hydrophobicity characteristic of gold and the flexibility of the water surface tension has played a critical role in heightening the efficacy of gold extraction. The surface tension of water or any solution refers to the microscopic membrane that forms at the surface. The formation of the membrane is necessitated by the strengthening of the usually weak van der Waals forces that binds the water molecules together. The use of additives such as the ferrous sulfide leads to increased polarity of the water molecules which essentially contributes to the strengthening of the bonds thus improving the surface tension of the water. Coil-oil is employed specifically as the source of the ferrous sulfide and to generate the froth that traps the gold dust.

The use of the ferrous sulfide in the method contributes to two most important characteristics that allow the extraction of the fine gold from the ores. First, the surfactant increases the surface tension of water which allows the gold particles to float at the top of the water surface.

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Again, the ferrous sulfide improves the cohesion forces of the gold particles thus allowing then to coalesce together. The main advantages if this method is that it improves the efficiency of extracting gold dust from the black soils. Furthermore, the ferrous sulfide is less toxic to the environment compared to other chemicals that are used in the extraction gold such as cyanide and mercury. Again, the efficacy of the method enables miners to extract high-quality gold from low-grade ores which cannot be done using any other method.

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