Use of the System $S_2o_3^{(2-)}$-O_2 for the Leaching of Precious Metals Contained in a Mineral From Molango in the State of Hidalgo, Mexico

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Doi: 10.19044/esj.2018.v14n3p48 URL:http://dx.doi.org/10.19044/esj.2018.v14n3p48

Abstract

The newer tendencies of research, related with the leaching of precious metals, involves the use of non toxic reagents that allows the leaching of a mineral of sedimentary origin using the system S_2 - O_3^{2-} - O_2. Prior to this process, the mineral was characterized by Scanning Electron Microscopy (SEM) in conjunction with Energy Dispersive Spectrometry of X – rays (EDS), X- ray mapping. Finally, the chemical composition was executed by Inductively Coupled Plasma Spectrometry (ICP). According to the results obtained, it was possible to determine that the mineral studied has adequate contents of gold, palladium, silver, and platinum. And after the leaching process, it could be possible to leach the gold and palladium that it contains, getting recoveries of 90% and 85 %, respectively. In the case of silver, a re-dissolution or precipitation could occur during the first minutes of reaction.

Keywords: Leaching, thiosulfate, gold, palladium

Introduction

Cyaniding is the most employed method to recover precious metals from its minerals all over the world. However, the scarcity of ore deposits which is easily leachable and the rising gold and silver prices, have forced the mining industry to process complex minerals that in many occasions can be refractory to cyaniding process. The conventional definition of a refractory mineral refers to the process where gold and silver recovery is below 80% using conventional cyaniding (Rodriguez, Nava & Uribe, 2014). However, from a scientific and technological point of view, this is the main problem faced by metallurgists; and this also is the reason new reagents such as thiosulfate needs to be to searched and probed (Salinas et al., 2015). In addition, it is friendly with the environment and it has a better affinity for precious metals. As a result, it looks for the best conditions of the process required to get an adequate recovery of silver.

On the other hand, minerals having gold and silver are typically classified as minerals for free or refractory grinding, based on their metallurgical response to cyaniding. As the free mineral resources (gold and silver) are rapidly depleted, one of the most pressing problems facing the gold and silver industry is in developing efficient and effective processes to extract these kind of metals from refractory minerals (Xian, Zhen, Bao, Han, & Jian, 2014). Also, the negative environmental and security aspects related to the cyaniding process, used for the recovery of gold, have promoted the study in this topic by searching for alternate leaching reagents. From the results found, the chloride, thiourea, and thiosulfate could serve as an alternative (Gurung et al., 2013). Senanayake (2005) carried out a critical study of the gold leaching in systems without cyanide, particularly using thiosulfate as ligand. According this author, silver dissolved faster than gold, and silver (I) catalyses the dissolution of gold (Rivera, Patiño, Roca & Cruells, 2015). In Hidalgo State, mining industry is the most important economic activity with a hug tradition from the pre-Hispanic era to this present day (Hernández, Rivera, Patiño & Juárez, 2013). Consequently, among the problems found in the recovery of this metals, principally silver, it can be pointed that the existence of pyritic and quartz minerals, where values of precious metals are encapsulated, are the most important problem found in conventional cyaniding processes (Juárez, Rivera, Patiño, & Reyes, 2012). Also, mining region of Pachuca – Real del Monte contains minerals of the hydrothermal type, rich in lead, zinc, gold and copper, of the tertiary age for this mineralization. Basically, it is sub-divided into two districts; the first one embraces the counties of Pachuca, Mineral del Monte and Mineral del Chico, while the second one comprises of the counties of Del Arenal and Actopan, principally having Au-Ag (Hernández et al., 2012).

Finally, this work is related to the use of thiosulfate as leaching reagent for its use in the treatment of natural mineral for leaching of precious metals.

Experimental Procedure

The experimental procedure employed in this work embraces the stage of sampling, the conditioning of samples, characterization, and finally the leaching stage using thiosulfates as a leaching reagent.

Sampling

Sampling and conditioning were carried out by using the quartering method. It was done by treating samples taken into several points of the outcrop (such as seen in Figure 1) that are representative. From the overall sample taken, the quartering process will provide the samples to be used in the characterization and leaching stages.

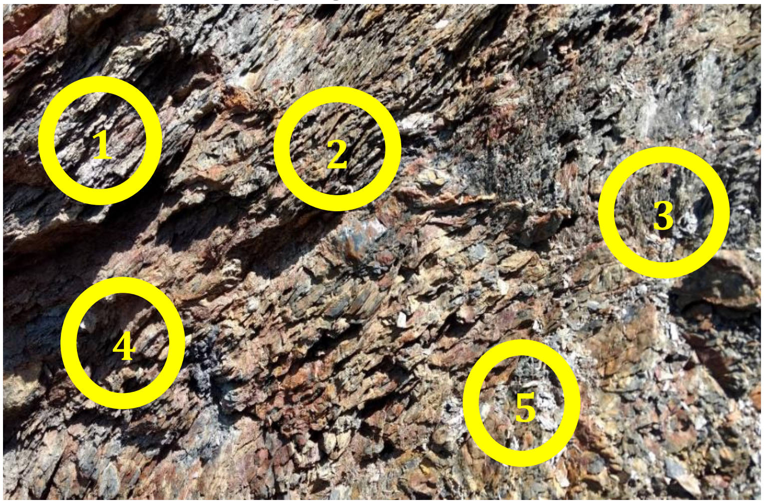

Figure 1. Points of sampling in the outcrop found

Characterization

Density Determination

The calculation of density was done using a test tube (Figure 2). Here, 500 ml of water and 100 g of mineral was added to the test tube. By volume difference, the value obtained was 2 *g/cm*^{3}.

Figure 2. Determination of density by volume difference in a test tube

Granulometric Analysis

Determination of Particle Size

In the determination of particle size, the sample was crushed and grinded to reduce particle size. After then, it was sieved using the Tyler series of meshes. The results in Table 1 show the size distribution mesh by mesh for each retained size. From the table, it can be observed that the major amount of retained particles is in the mesh 200. Thus, this shows an average particle size of 74 µm.

Table 1. Size distribution found by the granulometric analysis done

Mesh	Gr	Mesh	gr
80	16.5	230	10
100	12	270	4
120	10	325	5
140	9.5	400	5.5
200	17.5	>400	10

Mineralogical Analysis by Scanning Electron Microscopy

A Scanning Electron Microscope Jeol Brand model JSM-IT300 was used for examination of representative samples and to determine morphology, particle size distribution, and punctual semi quantitative analysis by Energy Dispersive Spectrometry of X – ray in conjunction with X - ray mappings. Figure 3 shows the result obtained. Here, it shows the analysis of the particles from samples denoting an EDS spectrum and X – ray mapping, showing the located presence of Au, principally.

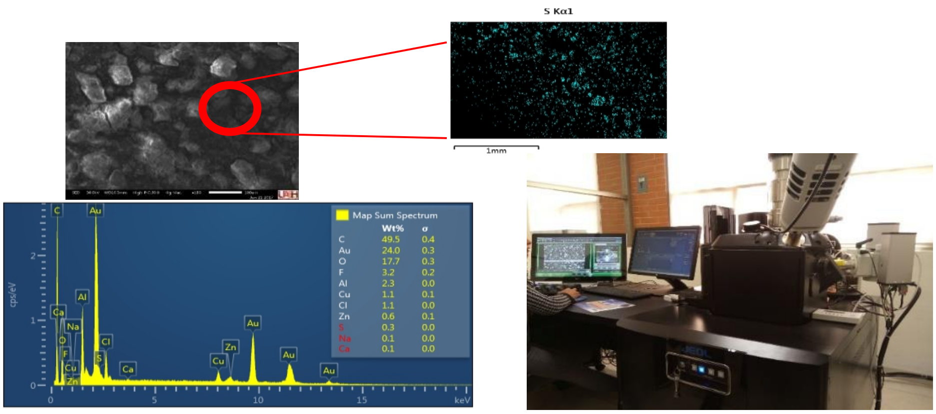

Figure 3. Results found by characterization using a Scanning Electron Microscope

Leaching of Mineral using Thiosulfate

The leaching experiences were carried out in varying concentration of thiosulfate and the addition of copper sulphate. Table 2 shows the experimental conditions used in the four (4) experiments that was conducted. Here, it can be observed that only the amount of mineral, volume of solution, time of reaction, pH, and stirring rate were kept constant.

During all the experiments, pre fixed times were selected to take samples that were used to determine the amount of precious metals extracted for the case of gold, silver, palladium and platinum, respectively. Figure 4 shows the result obtained during the experiments of leaching carried out. It can be seen that for the case of gold and palladium, there were an adequate extraction. Therefore, this means that thiosulfate is useful for the recovery of these kind of metals. However, in the case of platinum, it can be observed that this leaching reagent is not effective for extracting it. On the other hand, silver appears to be rapidly leached; but after the leaching, the decreasing of silver extracted could be due to a precipitation of this metal. This occurs due to the selectivity of reagent for gold or perhaps the content of copper could reduce the complex silver.

Table 2. Experimental conditions for the experiments of leaching determined by ICP

Experiment	Mineral amount (g)	Thiosulfate amount (g)	Volume (ml)	Copper sulfate (g)	pH	Time (min)	rpm
1	20	39.5	500	0.25	10-11	180	750
2	20	10	500	0.35	10-11	180	750
3	20	39.5	500	0	10-11	180	750
4	20	10	500	0	10-11	180	750

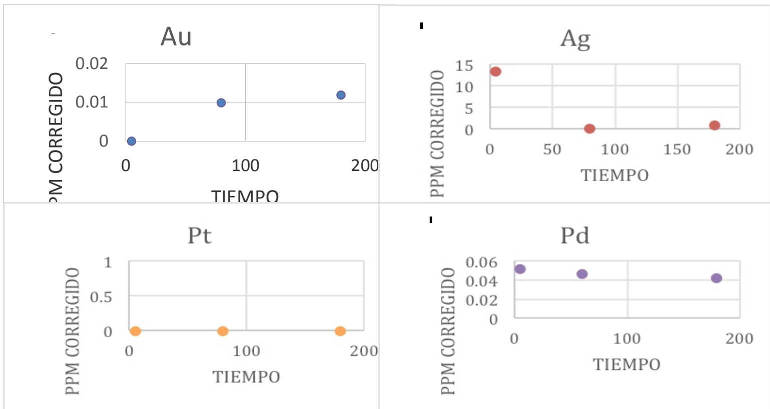

Figure 4. Leaching results for the extracting of precious metals: a) Gold, b) Silver, c) Platinum, and d) Palladium

Conclusion

Based on the characterization, the presence of gold and other precious metals in adequate amounts to be leached could be confirmed.

On the other hand, the use of sodium thiosulfate as a leaching reagent has a good effect for the recovery of gold and palladium, getting recoveries of 90% and 85 %, respectively.

In the case of Platinum, the used reagent has no effect on its recovery. Finally, for the case of silver, a rapid leaching could be appreciated; but after the process, there is going to be a decrease in the content of silver in the solution. However, this can be due to re-dissolution of the metal or a precipitation from its ionic forM.

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