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ENHANCED PRECIOUS METALS RECOVERY BY THE MEANS OF COMBINED PROCESSING OF GOLD BEARING - LOW GRADE COPPER ORE

S S. Gaydardjiev
Department of Mineral Technologies, University of Mining and Geology, 1 100 BG, Sofia

ABSTRACT: The possibility for increasing the gold recovery from copper ore derived from Burgas region by combined processing - flotation and thiourea leaching is investigated. For the purposes of selective flotation recovery of the precious metals, four collectors supplied by Cyanamid company were tested, namely - Aero 412 and 853, Aerophine 3418 and Aerfloat 3477. The best result achieved with Aero 412, Further on, three technological criteria were studied by the means of regression analysis - pH, degree of milling and addition of urea as activator of gold flotation. The final flowsheet proposed encompasses leaching of the remaining tailing product with thiourea in acid media.

1. INTRODUCTION

Owing to the tendency for constant depletion of the existing free milling gold ores, it is conceivable that for the near future the complex gold bearing copper ores will represent considerable resources both in precious metals and in base non-ferrous metals and sulphur and a search for effective processing options is mandatory (Oudenne et al., 1986) Each year in Bulgaria a limited amount of gold is produced mainly as by-product from such kind of ores. Most of this gold is produced in metallurgical refining stage from flotation concentrates derived from the following deposits 'Chelopech[1]", Tslatzite" "Assarel", 'Zidarovo" and others. The technological flow-sheets employed, encompass gravity, flotation and hydrometallurgical stages arranged in a single way or a combination between them Free liberated gold possess a behaviour similar to the sulphide minerals flotation Therefore its recovery in the collective concentrates usually is sufficiently high However, definite problems arise when choosing the best technological approach to treat the gold bearing collective concentrates, especially in case of pyrite, arsenopyrite and zinc concentrates for which pyrometallurgical methods are not suitable Therefore it is evident that a search for technological regime based on selective reagents aimed at free liberated gold recovery in a separate concentrates is extremely viable. The presented research aims to scope this issue.

2. EXPERIMENTAL

2 1. Materials

The mıneralogıcal composition of the ores from Burgas region, subject of the presented research, indicates that these ores are of vein type. Generally these are primary sulphides, presented by disseminated chalcopyrite Other major minerals presented are pyrite, magnetite, spéculante, molibdenite. The presence of pyrite and its strong correlation with chalcopyrite stipulates a better liberation to be aimed in order to achieve satisfactory copper grade and recovery in the concentrates. The ore from various deposits in the region like 'Zidarovo", 'Varlı brjag", and 'Rossen' are transported and blended for processing in the 'Rossen" flotation concentrator An interesting and unique characteristic of this flotation plant is that it employs sea water from the Black sea The mean chemical composition and the phase distribution of copper in the ore treated in the 'Rossen" flotation plant is presented in Tablel and Table 2 respectively

Table 1. Characteristic of the ore processed in "Rossen" flotation plant

Element/Componen t	Cu	Fe	Al_2O_3	S	Sit).	Density
%	0 93	8 73	12	1 98	40 5>	2 8 g/cm'

Table 2. Phase analysis of copper

Cu as	primary sulphide	secondary sulphide	free oxide	associated oxide
%	86.92	7-10	2-4	1 -3

Ore minerals account to 15 %, while the gangue minerals to 85 %. Free gold is observed in the following size ranges (mm). - 0.5, +0 1, +0 02 Gold is most frequently observed m irregularly formed particles having the following shapes: lamella, oval and wire-like. Most often gold is finely disseminated and associated with quartz and rarely with carbonate minerals. However, it associates with sulphide minerals like pyrite, galena and sphalerite as well. Gold is found as native gold and electrum Native gold particles have isometric form in the stze range from 10 to 100 microns with an average of 50 microns. The electrum is found in elongated forms in the size vange from 20 to 200 microns and an average of 90 microns.

For the sake of focusing particularly on the flotation behavior of gold minerals, the presented study is performed using a sample taken from the Zidarovo ore field, which is characterized by higher gold content. The chemical composition of the sample is given in Table 3.

Table 3. Chemical composition of the sample from "Zidarovo" deposit

Element	Cu	Fe	AI	S	Pb	Z n _	Mn	Au	AR
Content, %, g/t	0,2	S	4.8	28	0.13	0.07	0.3	2	3.2

It İs evident that the main economic components in this ore which should be a potential recovery target are the precious metals.

2.2. Flotation Studies

Grinding of the ROM crushed ore was done in a laboratory ball mill up to 62%, - 200 mesh. Rougher and scavenger flotation were performed in a laboratory Denver type machine. In order to mimic the technological conditions of the plant, the experiments were performed with salty sea water from the Black sea having 12 72 g/l NaCl content and pH 6. Chemical analysis were performed by ICP-AES. Fire assay of the precious metals proceeds their determination by ICP-AES.

The following reagents (collectors and promoters), kindly supplied by CYANAMID-CYTEC representative in Bulgaria were investigated: Aerofloat 3477, Aero 412, Aerophine 3418 and Aero 853. They were used as 1 % emulsion. Pine oil was used as frother and was added in the rougher flotation with dosage of 50 g/t. The flowsheet used is presented at Figure 1 below.

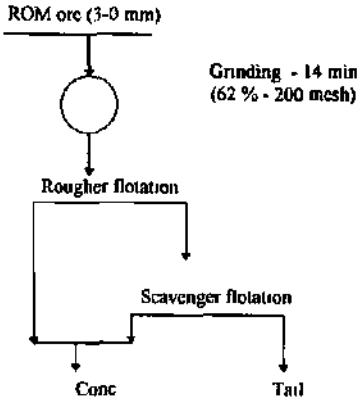

Figure I Flotation flowsheet for processing "Zidarovo" ore

As a first step it was decided to test all the four collectors at different dosages of 10, 20, 40 and 60 g/t and outline how they influence gold recovery The aim was practically to find out the best reagent and degree of addition From this set of experiments it was found out that the best results as regards gold recovery was achieved with AERO 412 at 40 g/t dosage rate Gold grade and recovery m the concentrate reached the figures of 13 g/t and 95 % respectively In previous studies it had been proved that urea addition as an activator for the gold minerals is beneficial in view of increasing recovery of gold (Gaydardjiev et a1, 1992) Therefore, further on it was proceeded with optimization of the technological regime to find out the optimal grinding time, pH and to study the influence of urea addition m combination with AERO 412 In order to reduce the total number of tests required, the experiments were planned according to the method of orthogonal-central-compositional planning The purpose was to obtain a regression equation which will represent the statistical characteristic of the optimal parameters In Table 4, the technological parameters studied are presented

Table 4 Technological parameters and their degree of variance

Factors/ Level	XI grinding time, mm	X2 pH	X3 urea addition, g/t
Base level	13	6 5	30
Step	6	1 5	16 5
Maximal level	19	8	46 5
Minimal level	7	5	13 5

The parameter Y = y ß, was chosen as an optimization criterion Fifteen experiments were considered sufficient to cover the studied range in the correlation matrix After the indispensable mathematical procedures the following equations m normal and standard scale were obtained

$$y = -0\ 22 + 0\ 044x, + 0\ 523x_2 + 0\ 017x, + 0{,}019x,x_2 - 0\ 0004x,x_3 + 0\ 0Q3x_2x, - 0\ 005x,^2 - 0\ 0704x_2^3 - 0\ 0005x_3^2 \quad (1)$$

$$Y = 2\ 039 + 0\ 1505X, - 0\ 0839X_2 + 0\ 0287X, + 0\ 1759X,X_2 - 0\ 0425XiXs + 0\ 0951X_2X, - 0\ I84IX,^2 - 0\ I585X_2^2 - 0\ I584Xr \quad (2)$$

The optimal values for the technological factors were found as follows

- grind ume - 16 minutes
- pH - 6 7
- urea addition - 31 g/t

As seen from the equation (2), the factors having maximum influence on the optimization criterion Y are the milling time (Xi) and pH (X_2) In order to visualize their effect better, a graphical relationship is presented at Figure 2

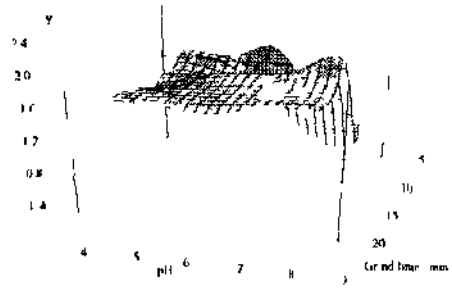

Figure 2 Zidarovo ore flotation - effect of grinding time and pulp pH upon the optimization criterion Y ~ y ß

After substituting the optimal values found out from the equation shown above, the value for the parameter Y was estimated as 2 283

Finally in order to validate the equation-model, experimentally flotation tn locked cycle involving scavenger operation was performed under the optimal conditions The flowsheet and the reagent addition are presented at Figure 3

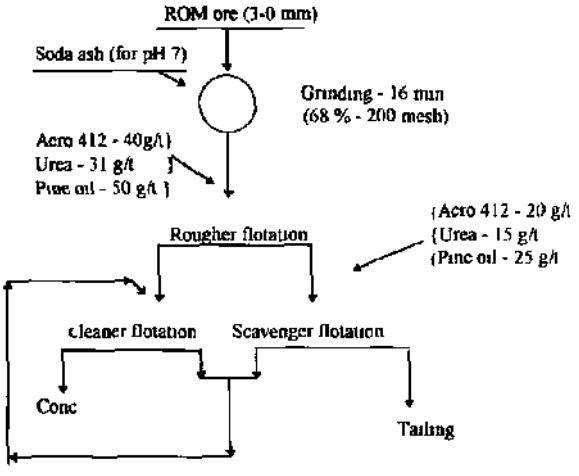

Figure 3 Flotation flowsheet for processing "Zidarovo" ore under the optimal conditions

Table 5 Precious metals recovery from Zidarovo ore with locked cycle flotation

Product	Yield, %	Grade, g/t		Recovery, %	
		Au	AR	Au	Ag
Concentrate	5	36 57	46 19	91 42	72 18
Tailing	95	0 18	0 94	8 58	27 82
Raw ore	100	2	3 2	100	100

Table 5 summarizes the results obiamed using the above flowsheet under the optimal conditions As can be seen from Table 5, quite satisfactory results for gold grade and recovery were achieved under the optimal conditions suggested by the mathematical model

2 3 Thiourea Leaching of the Tailing Product

Finally an attempt was placed to recover the gold remaining in the flotation tailing by hydrometallurgical treatment Owing to the well known drawbacks associated with cyanıdatıon, we have decided to study thiourea leaching - an approach which has proved feasible in our previous studies with a similar ore Agitation leaching was performed in sulphunc acid media (0 IN), solid-liquid ratio was kept 1 I and thiourea addition - I S kg/ı (based on previous studies) As a result of the thiourea leaching gold content in the final barren cake after filtration decreased to 0 05 g/t, which indicates that about 86 % was recovered in the pregnant solution

3 MAIN CONCLUSIONS

- It was found out that the reagent AERO 412 selectively floats gold from a gold bearing copper sulphide ore
- The degree of grinding connected with minerals liberation and pulp pH have a pronounced influence on gold grade and recovery of the flotation concentrate The optimal values for the technological parameters established from a regression analysis guaranteed the satisfactory gold grade and recovery m a sepaiatc concent! ate

The gold remaining in the tailing could be successfiilly recovered via acid thiourea leach route However, it should be emphasized that further studies are needed to assess the overall economic feasibility of the latter operation

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