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NEW SELECTIVE COLECTOR FOR FLOTATION OF SULFIDE ORES

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ABSTRACT
A purposefully synthesized reagent was applied as an additional collector to the flotation of integral sulfide ores. Investigations were carried out with real ore under laboratory conditions in an open and closed cycle. Technological properties of the new reagent were studied for different slurry density and different mode of grinding. It was established that use of an additional reagent collector, supplied into the grinding process allows significant enhancement of gold recovery from collective copper-pyrite concentrate.
Key words: flotation, gold, collector

INTRODUCTION

General technology for flotation of sulfide auriferous ores employs xanthogenate as a main collector. Pyrite for this type or ores is depressed with significant quantities of lime. As it is known, large quantities of calcium oxide, available in the flotation slurry depress the elementary gold and reduce its recovery in copper pyrite concentrates (*Boteva, 1992*). Use of additional collectors for enhancing gold recovery in sulfide concentrates is rarely practiced. Gold recovery is low under these conditions. The high rate of lime consumption depresses it, and xanthogenates are insufficiently effective gold collectors, especially in the cases, when particles of elementary gold are covered with iron hydroxide.

A new reagent collector is synthesized for avoiding the above disadvantages in the industrial technology for selective, gold-containing ores. Synthesis is performed on the basis of cheep chemicals, large quantities of which are produced by chemical industry. The reagent is water-soluble and most probably contains two functional groups. The two functional groups provide high rate of gold recovery in sulfide concentrates, forming most probably, a hepatic ring with the metallic catione. Rate of gold recovery is not accompanied with reduction of copper sulfide recovery. Technological properties of the new collector were studied under laboratory conditions with tests in the open cycle.

SETTING OF THE EXPERIMENT

The synthesized new reagent – collector is analyzed by infrared spectroscopic methods (fig. 1). It is subjected to analysis in its natural type. It is studied in the domain from 5 to 40x100 cm^{-1}. This is the field, where C=S, C-S, SH, N-C, N-C-O connections will be revealed.

Laboratory investigations for technological properties of newly synthesized reagent-collector are carried out with real ore under conditions of open cycle according to the schemes sin figures 2 - 4.

Three types of ore are investigated: from the Elatsite, Chelopech and Asarel, respectively.

Mineralogical characteristic of the assay from Elatsite deposit

A total of 61 minerals are established in the ores of the Elatsite deposit, including 48 ore minerals and 13 non-ore minerals. They are subdivided into major, secondary and rare. Major ore minerals are chalcopyrite and pyrite, secondary minerals are bornite, molybdenite, native gold, electrum, hematite etc., non-ore minerals are presented as quartz, potassium feldspar, biotite etc.

Ores in the Elatsite depsoit are divided into three sorts: sulfide copper ores - not more than 10 %, mixed ores – oxide copper from 10 to 30 % and oxides with oxide copper more than 30 % Average copper content indifferent sorts of copper is the following:

Sulfide ores in granodiorite rocks:	0.43%
Sulfide ores in schistous rocks:	0.38%
Mixed ores in granodiorite rocks:	0.32%
Mixed ores in sschistous rocks:	0.32%

Major source of copper in the sulfide ores is the chalcopyrite – nearly 78%, then follows the bornite – 22%.

Content of gold is as follows:

Economic sulfide ores:	0.14 g/t
Economic mixed ores:	0.13 g/t
Non-economic oxide ores:	0.18 g/t

Content of sulfur and pyrite varies from 0.1 to 2.3%.

Mineralogical characteristic of the assay from the Chelopech deposit

The most important economic value of the deposit is determined by the mineral association of copper-arsenic-gold. It is characterized with the high concentration of sulfosalts. The major minerals are: pyrite, enargite, bornite, tenantite, chalcopyrite, accompanied by gold and gold-containing minerals. Pyrite is the mostly available mineral. It is represented by fine granular aggregate, and pyrite crystals are rarely available. The sphalerite is available as isolated injections in altered tuffs and compact masses, together with other minerals, as well. The galena is available at periphery of the ore body, where it is incorporated in lead-zinc deposits together with pyrite and sphalerite. The tenantite is bound in a pyrite-bornite-chalcopyrite association and contains not only copper, arsenic and sulfur but also tellurium and tellurium-containing sulfosalts. This association is the main carrier of gold.

Most important rock-forming minerals are quartz and barite. The quartz forms granular aggregates of grain size of several microns. The barite is distributed as natural, coarse granular, almost mono-mineral deposits, formed in the marginal parts and above the ore bodies.

Mineralogical characteristic of the assay from the Asarel deposit

The deposit is of porphyry copper type. Ore reserves are calculated in three sorts: oxides, mixed sulfide-oxide and primarily – sulfide. Other copper minerals are bornite, chalcopyrite, covelline, copper oxides and sulfates. Copper is the major economic component of the deposit. There are several parageneses at the deposit. Major minerals at the feldspar – biotite – magnetite parageneses are potassium feldspar, biotite and magentite, and the secondary are epidote, aduare, chlorite, specularite, quartz. Pyrite is the only ore mineral in the quartz-sericite-pyrite paragenesis. It is available in fine veinlets or accumulations. Major minerals in the quartz-pyrite-chalcopyrite paragenesis are pyrite, chalcopyrite and quartz and secondary are molybdenite, tenantite, tetrahedrite etc.

The major primary ore mineral in the deposit chalcopyrite. It is totally available and appears as veinlet injections in both sericite rocks and slightly changed propilitized diorite porphyrites.

Major secondary ore mineral is the chalcosine, pyrite also has economic importance. The chalcosine is the most widely distributed mineral in the mixed sulfide-oxide ores. Furthermore, in the deposit there are bornite, coveline, malachite, azurite, natural copper and natural gold.

Technical characteristics

Flotation tests are carried out in a Denver flotation cell, 1500 revolutions/min with a cell capacity of 4 liters for the rough and 2 liters for the scavenge flotation.

Slurry density is different according to type of material and particular flotation conditions. Grinding is performed in a ball mill of 105 revolutions/min. The solid – liquid ratio is 1:1 in its volume. Mill loading with balls is as follows:

Table 1. Granular composition of mill loading with balls

Diameter of balls, mm	8	8÷17	17÷20	20÷28
Quantity, кг	1	2.2	2	0.8
yield, %	17	36.6	33	13.1

The reason for testing with three types of sulfide ores – from the deposits of Elatsite, Chelopech and Asarel, respectively is observing the behaviour of newly synthesized reagent for different mineralogical composition of the ore.

RESULTS FROM EXPERIMENTS

A new compound characterized by the following infrared spectrum is synthesized on the basis of several initial substances (figure1).

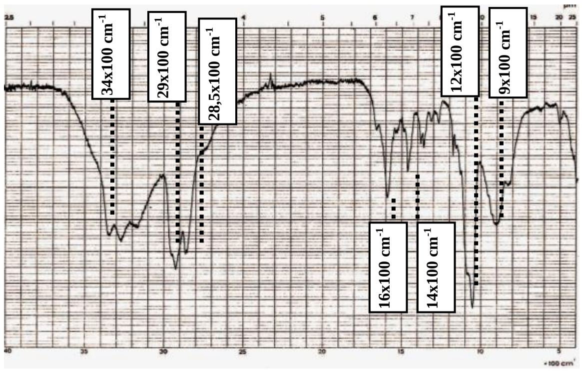

Figure 1. Infra-red spectrum of newly synthesized reagent – collector.

The new compound is water-soluble, crystallizing in regular rhombohedral, transparent, light yellow crystals. The infra red spectra show availability of S=C, -S-H, CH_2 – S - CH_2, HO-CH_2 links. The availability of these links suggests availability of two functional groups, fastened to a common hydrocarbonic - radical. The last suggests good technical behaviour for flotation of sulfide copper gold-containing ores, especially for gold metallic cations, which are expected to form hepatic rings. Investigations for establishing of technological characteristics of the reagent are carried out with ores from the Chelopech, Elatsite and Asarel deposit, respectively, for the above-mentioned reason.

Experiments on ore from the Elatsite deposit

Experiments on assays from the Elatsite deposit are carried out according to the flowsheet in fig. 2. Results are represented in table 2 and graphically shown in fig. 5. They reveal rate in gold recovery without disturbing the recovery of copper for consumption 15 g/ton, fed into grinding. Deterioration of output for consumption higher than 15 g/ton is most probably caused by the formation of poly-layered coating of the new collector.

Experiments on ore from thee Chelopech deposit

Objective of experiment is improving the recovery of gold and copper in the collective concentrate by the use of additional reagent-collector. Tests are carried out according to the scheme in fig. 3 and results are represented in table 3 and figure 6. The best results for gold and copper are obtained for consumption of newly synthesized reagent of 20g/ton.

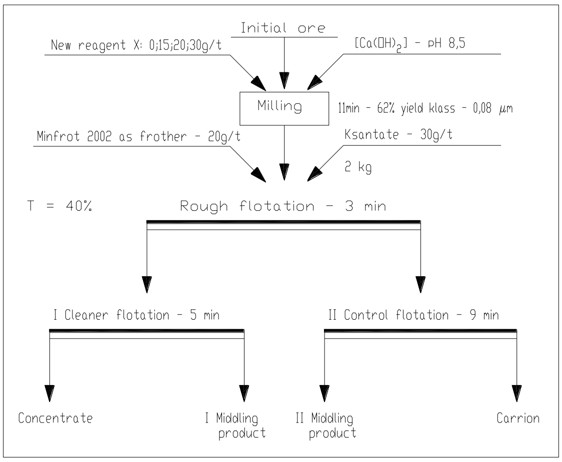

Figure 2. Flowsheet for ore from the Elatsite deposit

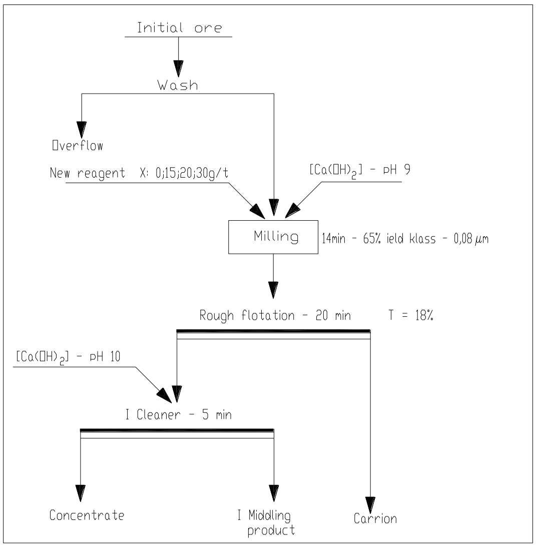

Figure 3. Flowsheet for ore from the Chelopech deposit

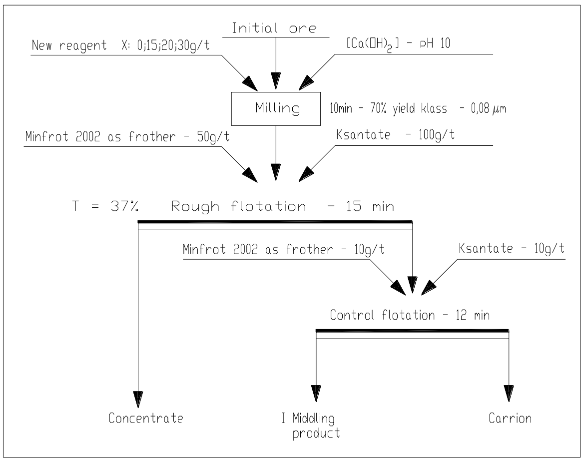

Figure 4. Flowsheet for ore from the Asarel deposit

Experiments on ore from the Asarel deposit

Experiments are carried out according to the flowsheet in figure 4. Results are shown in table 4 and figure 4. The best results for recovery of gold and copper are obtained for consumption of the newly synthesized reagent of 20 g/ton.

Table 2. Results from flotation tests on ores from the Elatsite deposit for different consumption of newly synthesized reagent

Addition of collector	Products	yield γ %	Content β,%			Recovery ε, %		
			Au	Cu	S	Au	Cu	S
			g/t	%	%	g/t	%	%
0 g/t	concentrate.	2,67	5,65	16,9	21,97	50,66	67,12	61,36
	I middle product.	2,86	0,86	1,86	2,80	8,25	7,90	8,36
	II middle product..	5,03	0,68	1,26	2,20	11,48	9,42	11,57
	waste	63,00	0,14	0,166	0,284	29,59	15,54	18,69
15 g/t	concentrate.	3,09	5,82	14,35	18,5	83,33	73,85	71,16
	I middle product.	2,70	0,16	1,43	2,02	1,99	6,42	6,78
	II middle product..	3,70	0,35	1,06	1,35	5,99	6,52	6,20
	waste	62,50	0,03	0,127	0,204	8,67	13,20	15,84
20 g/t	concentrate.	2,225	5,25	13,57	16,85	70,44	60,01	67,83
	I middle product.	2,90	0,24	1,88	2,35	4,19	10,83	12,33
	II middle product..	3,75	0,55	1,39	2,00	12,43	10,36	13,56
	waste	63,00	0,034	0,15	0,055	12,91	18,78	6,26
30 g/t	concentrate.	2,10	5,87	16,5	20,8	77,20	79,37	88,40
	I middle product.	2,65	0,24	0,94	1,40	3,98	5,70	7,50
	II middle product..	2,925	0,35	0,15	0,37	6,41	1,00	2,19
	waste	66,00	0,03	0,09	0,01	12,40	13,91	1,89

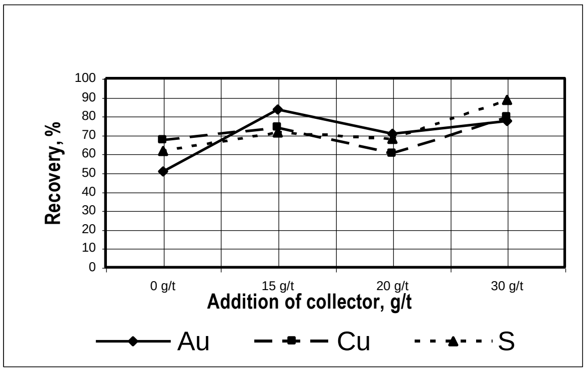

Figure. 5. Recovery of Au, Cu and S as a funtion of new collector addition - "Elazite" mine

CONCLUSIONS AND DISCUSSION OF RESULTS

Experiments with the three types of ore revealed:

1. The new reagent enhances recovery of gold and much less recovery of copper, without deteriorating the quality of concentrates.

2. The three rounds of experiments show an optimum for rate of consumption. Rate of consumption is higher for ores of higher content of sulfide minerals (Chelopech) or availability of very fine slimes that increase adsorption of collector, due to its larger relative surface. This confirms the suggestion for poly-layered adsorption of additional collector.

3. It may be suggested that for a certain rate of collector consumption the availability of more than one functional group changes the structure of adsorption layers and brings to hydrophilizatoin of gold particles.

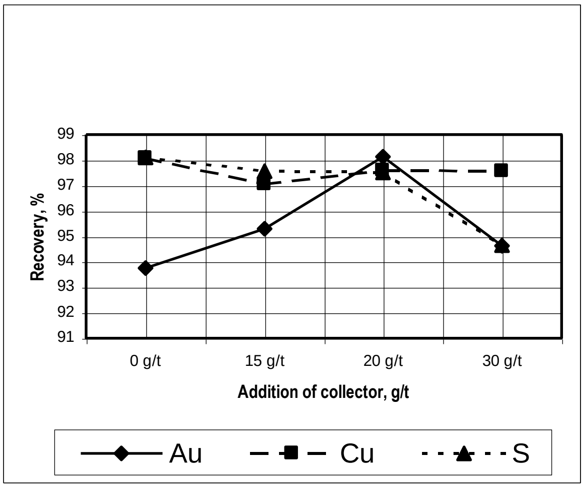

Figure. 6. Recovery of Au, Cu and S as a funtion of new collector addition - "Chelopech" mine

Table 3. Results after flotation experiments with ore from “Chelopech” mine by using of diferent addition of a new reagent”

Addition of collector	Products	yield γ %	Content β,%			Recovery ε, %		
			Au	Cu	S	Au	Cu	S
			g/t	%	%	g/t	%	%
0 g/t	concent rate	48,93	9,03	9,14	46,2	93,74	98,08	98,10
	Middle product	9,36	1,99	0,56	4,62	3,95	1,14	1,87
	waste	41,71	0,26	0,08	0,01	2,30	0,76	0,02
15 g/t	concent rate	51,14	9,40	4,14	21,77	95,28	97,03	97,57
	Middle product	9,09	1,17	0,33	2,97	2,10	1,37	2,36
	waste	39,77	0,33	0,087	0,01	2,60	1,58	0,06
20 g/t	concent rate	51,57	9,7	3,61	19,62	98,12	97,58	97,51
	Middle product	5,66	1,2	0,46	3,67	1,33	1,36	2,00
	waste	42,77	0,06	0,047	0,11	0,54	1,05	0,47
30 g/t	concent rate	50,30	10,04	4,08	21,5	94,62	97,56	94,65
	Middle product	5,99	2,89	0,38	4,07	3,24	1,08	2,13
	waste	43,71	0,26	0,065	0,84	2,12	1,35	3,21

Table 4. Results after flotation experiments with ore from “Asarel” mine by using of diferent addition of a new reagent.

Addition of collector	Products	yield γ %	Content β,%			Recovery ε, %		
			Au	Cu	S	Au	Cu	S
			g/t	%	%	g/t	%	%
0 g/t	concentrate	6,324	0,590	3,480	24,380	47,119	78,504	90,534
	middle product.	7,601	0,030	0,170	0,830	2,880	4,609	3,705
	waste	86,073	0,046	0,055	0,114	50,001	16,887	5,762
	overflow	21,769	0,139	0,250	1,060	38,215	19,414	13,550
15 g/t	concentrate	6,870	0,787	3,570	25,170	65,941	84,104	92,679
	middle product.	6,870	0,030	0,110	0,570	2,514	2,591	2,099
	waste	86,218	0,030	0,045	0,113	31,545	0,292	5,222
	overflow	26,981	0,031	0,260	1,080	10,213	23,692	15,619
20 g/t	concentrate	7,292	0,920	3,670	25,980	71,911	84,668	92,608
	middle product.	8,036	0,010	0,150	0,670	0,861	3,814	2,632
	waste	84,670	0,030	0,043	0,115	27,228	11,519	4,760
	overflow	24,500	0,030	0,300	1,110	7,885	23,255	13,292
30 g/t	concentrate	6,430	1,315	3,850	27,980	33,464	76,678	85,531
	middle product.	3,890	1,556	0,230	1,140	23,955	2,771	2,108
	waste	89,660	0,120	0,074	0,290	42,581	20,551	12,361
	overflow	23,390	0,109	0,270	1,150	10,093	19,564	12,788

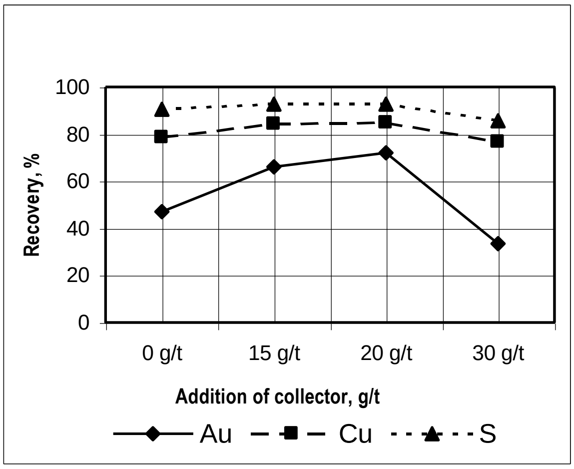

Figure. 7. Recovery of Au, Cu and S as a funtion of new collector addition - "Asarel" mine

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