

BARITE FLOTATION CONCENTRATE FROM KREMIKOV TZI “BLACK” TAILINGS

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Abstract

The main objective of this work is to prove the perspectives to obtain good quality barite concentrate from technological tailings (called “black tailings”) of “Chelopechene” Tailings Pond. They had been accumulated by 1989 when magnetizing roasting technology had been used in Kremikovtzi processing plant. Grindability and floatability studies of “black tailings” were performed. Laboratory flotation tests were carried out. The test data show that the “black tailings” could be beneficiated by flotation with suitable selection of reagents. The high quality barite concentrate with BaSO_4 content over 95 % and Fe – from 0.82 to 1.52%, at BaSO_4 recovery over 64 % could be achieved by using collector reagent ALP 611 or reagent mixture OMC 199 with Chemopen 3467 and ALP 611 with OMC 199 at ratio 3:1 and collector reagent dosage 600 g/t. The quality characteristics of the produced barite concentrate meet the international standards of class “A” and “B”.

Key words: barite, flotation, tailings

1. INTRODUCTION

Barite (spelled *baryte* in British publications) was named from the Greek word “*baros*” which means weighty, a reference to its unusually high specific gravity. Barite is the main industrial source of barium. However, the use of barium metal is minor and barite is usually used as an industrial mineral. It is relatively common and widely distributed, although the bulk of world production is supplied by only a few countries. The name barite is also given to the commercially traded mineral. The only other commercially available barium mineral is witherite (barium carbonate, BaCO_3). Witherite is much less common, but occurs in some barite deposits. Witherite is sought after for use in the chemical industry as it is more easily dissolved than barite.

Barite is a naturally occurring barium sulphate mineral (BaSO_4 in the proportion 66% BaO and 34% SO_3). Barite can sometimes contain strontium, and forms a complete solid solution series to the mineral celestite (SrSO_4). The color is usually white but can vary with the presence of impurities. A commercially important characteristic of barite is its relatively high density of 4.5 g/cm^3 – hence the old name “heavy spar”. Crystals of barite are water-clear and have a distinctive tabular shape, but radiating or “coxcorn” crystals also occur.

Depending upon purity of the ore, the low grade barite is beneficiated to meet the commercial specifications of the product. As per the mineralogy of the ore, the simple gravity based methods are not often suitable and concentration by froth flotation is required (Brobst 1983). Barite is also recovered as a by-product from sulphides by flotation route (Davis 1985; Singh et al. 2006).

Barite deposits are found throughout the world in a variety of geological environments (Fig. 1). The three major types of barite deposits are stratiform, vein and residual. Most barite is produced from stratiform deposits.

Mining methods vary with the type of deposit. Major stratiform deposits are worked by open pit where this is practicable. The ore is drilled and blasted and then trucked to the mill for processing. Conventional underground methods are used as appropriate to the shape and attitude of the deposit. Vein deposits are worked by shafts and adits, as well as by shallow open-pits. Residual deposits are mainly worked by hand, due to the variable and irregular nature of the mineralization.

Following initial crushing, some barite is sold as “direct shipping ore”, if it is sufficiently pure, to be processed for addition to drilling fluids at plants adjacent to oil fields. If there are contaminants, such

as waste rock or other minerals such as fluorite, quartz, galena or pyrite, these may be separated from the barite by gravity separation, wet grinding and froth flotation. The barite is then dried and sold as powder or processes further for particular applications.

Figure 1 presents the distribution of major active and inactive barite mines and significant deposits. The end-uses of barite and global barite production in 2012 are shown in Figure 2 and 3 respectively.

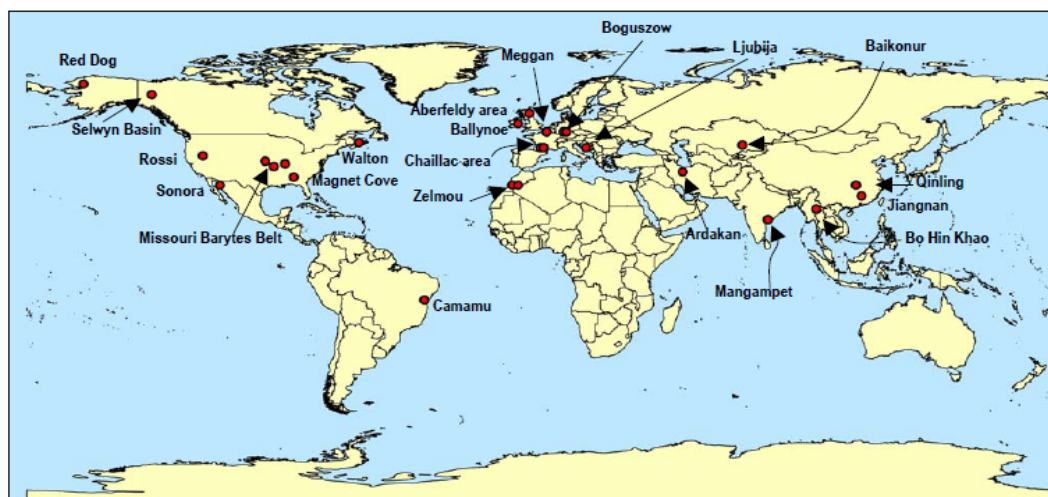


Fig. 1. The distribution of major active and inactive barite mines and significant deposits

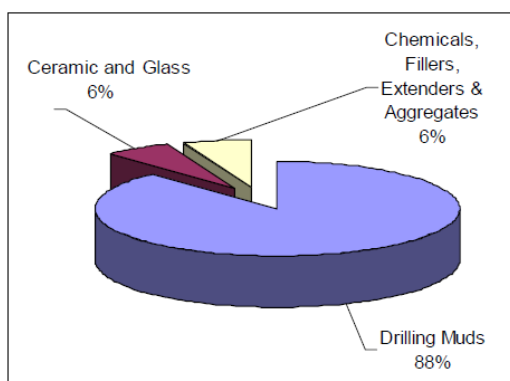


Fig. 2. The end-uses of barite

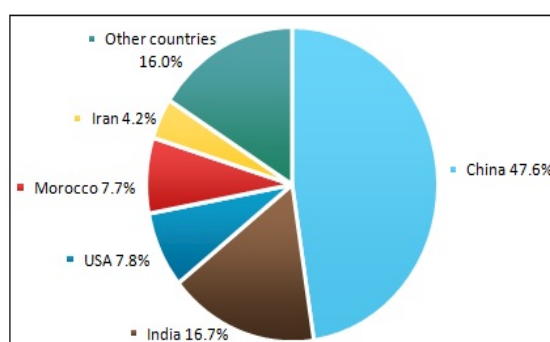


Fig. 3. Global barite production in 2012 (Barite Market Review and Forecast, <http://mcgroup.co.uk/researches/barite>)

Finely ground barite is added to the drilling fluid to increase the density of the column of fluid above the drill bit and thus assist in preventing a “blowout”. Barite can form up to 40% of the fluid by weight.

Barite particular qualities of high density, low solubility, high brightness and whiteness, chemical inertness, softness and relative cheapness also make it valuable in many other applications. These include: as filler in paint and plastics, as the main source of barium for the chemical industry, in glass manufacture as a flux and to add brilliance and clarity. The production of lithopone, which is a high performance white pigment, composed of a mixture of chemically precipitated and calcined zinc sulphide and barium sulphate. Titanium dioxide has largely replaced barites for this application, but there are still some specialized uses. Minor uses are as an absorber of gamma and X-ray radiation, e.g. special concrete to shield nuclear and X-ray installations. In the construction industry barite is

sometimes added to concrete to increase its density for specialist application. In medicine, it is used to highlight problems within the human body.

The specifications for each of these applications place limits on the levels of contaminant minerals or elements in barite. Natural barite commonly contains fluorine, strontium, lead, zinc or iron in undesirable amounts that have to be reduced by blending or treatment (Bonel 2005).

Barite concentrate of «A» class has a fairly wide range of applications, because the content of pure substance of barium sulfate is significantly higher than in the trademarks of «B» class (BaSO_4). So barite concentrate of «A» class is used in chemical, paint and coatings, asbestos-technical and other industries; barite concentrate of «B» class is used in gas and oil producing industry and in exploration industry for preparing a weighting agent or a weighting agent for drilling fluids.

Barite beneficiation processing is treatment of raw barite material to improve physical or chemical properties in preparation for further processing. Beneficiation techniques include crushing, screening of particulates, and concentration (which involves the separation of valuable minerals from the other raw materials received from a grinding mill) and washing. In large-scale operations, various distinguishing properties of the minerals to be separated (e.g., magnetism, wettability, density) are exploited to concentrate the desirable components. Physicochemical parameters of barite concentrate of «A» class should conform to the standards specified in Table 1. Physicochemical parameters of barite concentrate of "B" class should conform to the standards specified in Table 2.

Table 1. Normalized quality data of barite concentrates of "A" class

№	Parameter	Standart of the mark					
		CB-1	CB-2	CB-3	CB-4	CB-5	CB-6
1.	Fraction of total mass, %: BaSO_4 , min	95	92	92	87	85	80
2.	Fraction of total mass, %: SiO_2 , min	1.5	1.5	2.5	3.5	4.0	4.5
3.	Fraction of total mass, %: Fe_2O_3 , min	0.5	1.0	1.5	2.0	2.5	2.5
4.	Fraction of total mass calcium and magnesium in the count on the CaO , %	0.5	1.0	1.5	6.0	7.0	7.0
5.	Humidity in the dry production, %	2	2	2	2	2	2
6.	pH Index	6÷8	6÷8	6÷8	6÷8	6÷8	6÷8

Table 2. Normalized quality data of barite concentrates of "B" class

№	Parameter	Standart of the mark		
		CB-3	CB-5	CB-6
1.	Fraction of total mass, %: BaSO_4 , min	90	85	80
2.	Fraction of total water-soluble materials, fraction of water-soluble calcium	0.35 0.05	0.45 0.05	0.45 0.05
3.	Humidity in the dry production, %	2	2	2
4.	Fraction of total mass “+71 μm ”, % , max	6	6	6
5.	Density, g/cm^2	4.2	4.1	4.0
6.	Fraction of total mass “-5 μm ”, % , max	10	20	20

Research and development program has started to established opportunities to get marketable barite concentrates from Kremikovtzi barite technological waste (called “black tailings”), obtained after processing Kremikovtzi ore including magnetizing roasting. The main objective of this work is to prove the perspectives to obtain good quality barite concentrate from technological tailings (called “black tailings”).

2. METHODS AND MATERIALS

2.1. *Material quality characteristics*

The „Chelopechene” Tailings Pond contains:

- **“Raw tailings”**. Stocked at the top layer in Kremikovtzi Tailings Pond, they were accumulated from 1989 till 2010 and had been processed by 2010 in „Kremikovtzi” Mineral Processing Plant for the production of barite and iron concentrates.
- **“Black tailings”** (~ 28 million tons). They had been accumulated by 1989 when magnetizing roasting technology had been used. Nowadays, it can be clearly distinguished from „Raw tailings” by its darker color.

2.2. *Grindability study of "black tailings" non-magnetic fraction*

A representative sample of "black technological tailings" was studied. It was been crushed in advance to 0.5 mm and underwent dry magnetic separation, including rougher and cleaner operations in weak magnetic field. The reason to use weak magnetic field was that it had been proven that "black technological tailings" had high content of γ -hematite which is strong magnetic mineral. (Grigorova, Dzhamyarov, Nishkov 2014). The laboratory grinding tests were carried out in laboratory ball mill with the following parameters:

- Volume $V = 3.3 \text{ dm}^3$;
- Ball load 5 kg.

The grinding tests were carried out at ratio Solid : Liquid = 1:1 (330 g sample and 330 ml water).

Grinding time - 1; 2; 3; 5; 7; 10 min.

The fraction „-0.071mm” was size-controlled by the method of wet particle size analysis in sieve analyzer „Retsch”.

2.3. *Floatability study of "black tailings" non-magnetic fraction*

The laboratory open bench-scale flotation tests were carried out in laboratory mechanical flotation machine „Denver” with cell volume 1.1 dm^3 (for rougher flotation) and 0.6 dm^3 (for cleaner flotation). The flotation tests that were executed included one rougher, two or three (if necessary) cleaners in open circuit. Six collector reagents were used in the flotation tests as follow: ALT 38; Ch 3467; OMC 199; AP 825; AP 845; ALP 611. Dehydol 04 was used as frother reagent. Sodium silicate was used as depressant for the rock mass and pH regulator. A number of solutions were prepared in advance with concentrations as follow:

- Depressant reagent’s solution – 8 Wt%;
- Collector reagent’s solution – 2 Wt%;
- Frother reagent’s solution – 1 Wt%.

Sequence of reagents addition and agitation time:

Rougher flotation:

- Depressant reagent – 4 min.
- Collector reagent – 4 min.
- Frother reagent – 1 min.

First, second and third cleaner flotations:

- Depressant reagent – 1 min.
- Collector reagent – 1 min.

Then the flotation products underwent chemical assay of Fe and BaSO₄. The flotation tests were carried out as per the flowsheet and reagent regime shown in Figure 4.

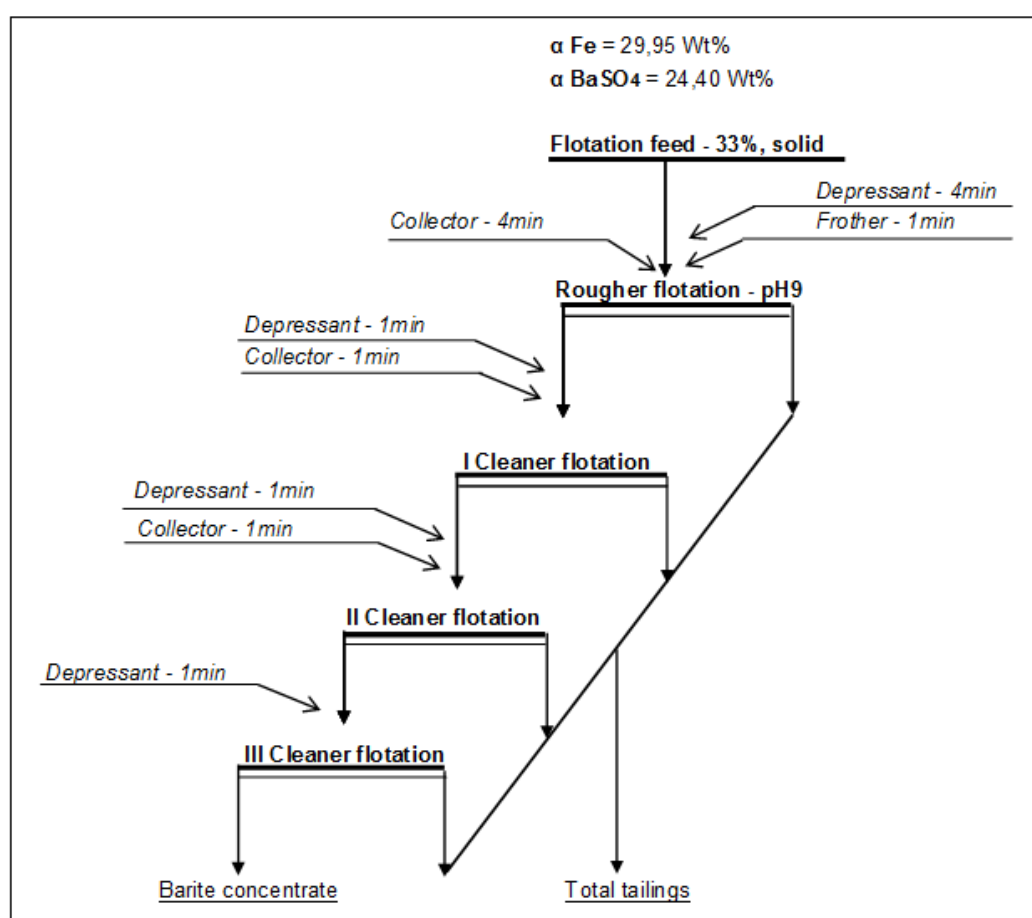


Fig. 4. Open cycle flotation tests flowsheet

2.3.1. Study of the influence of collector reagent dosage on floatability of "black tailings non-magnetic fraction"

In order to find out to what extent the floatability is influenced by the collector reagent dosage for obtaining high quality barite concentrate, 30 flotation tests were conducted using 6 types of collector reagents: OMC 199, AP 825, AP 845, ALT 38, Chemopen 3467, ALP 611. Each of the collector reagents was used in 5 different flotation tests with different dosages.

2.3.2. Study of the influence of collector mixtures dosages on floatability of „black tailings“ non-magnetic fraction

- Collector mixture of OMC 199 and test reagents at ratio 3:1 or 1:1

For obtaining high quality barite concentrate 24 flotation tests were conducted with 5 collector mixture types. The collector reagent is mixture of OMC 199 and AP 845, ALT 38, Chemopen 3467 at ratio 3:1 or 1:1. Each one of the mixtures underwent 4 flotation tests with different collector reagent dosages. In addition, 4 supplementary flotation tests were carried out using mixture of OMC 199 : Chemopen 3467 at ratio 3:1, including third cleaner operation, to achieve higher quality barite concentrate.

- Collector mixture of ALP 611 and test reagents at ratio 3:1 or 1:1

To produce high quality barite concentrate 16 flotation tests were conducted with 4 collector mixture types. The collector reagent is mixture of ALP 611 and OMC 199, AP 845 at ratio 3:1 or 1:1. Each one of the mixtures underwent 4 flotation tests with different collector reagent dosages.

3. RESULTS AND DISCUSSIONS

3.1. Grindability study of "black tailings" non-magnetic fraction

The grindability curve of representative sample is presented in Figure 5.

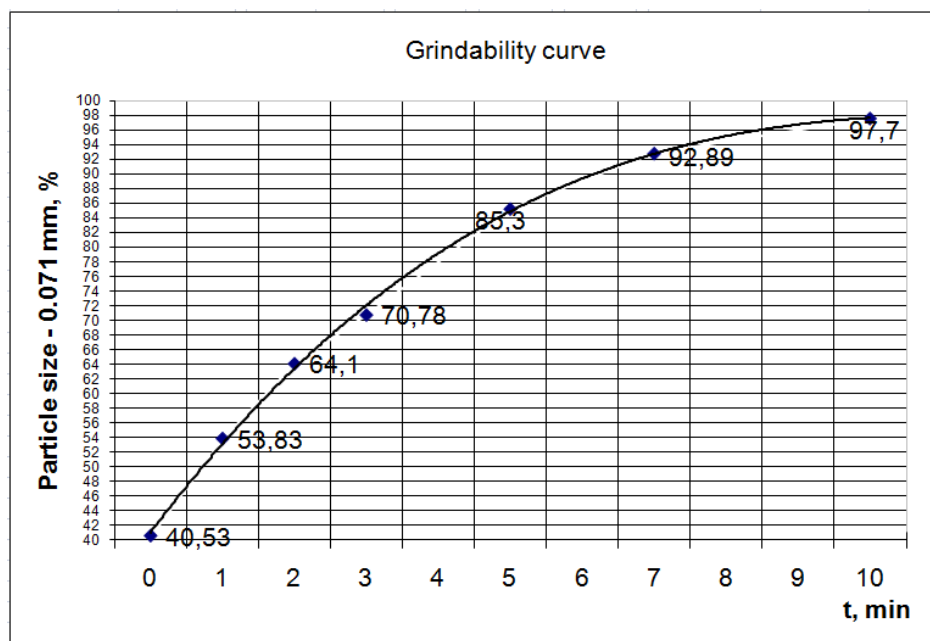


Fig. 5. The grindability curve of representative "black tailings" sample

Based on the laboratory grinding tests of "black tailings" non-magnetic fraction the optimal grinding time has been determined to be 1.5 min. The content of „- 0.071 mm“ fraction for this grinding time is about 60%. The grinding time of 1.5 min has been accepted as permanent for all flotation tests due to good mineral liberation.

3.2. Floatability study of "black tailings" non-magnetic fraction

3.2.1. Study of the influence of collector reagent dosage on floatability of "black tailings" non-magnetic fraction

The dependence of barite concentrate yield on the different collector reagent dosages is presented in Figure 6.

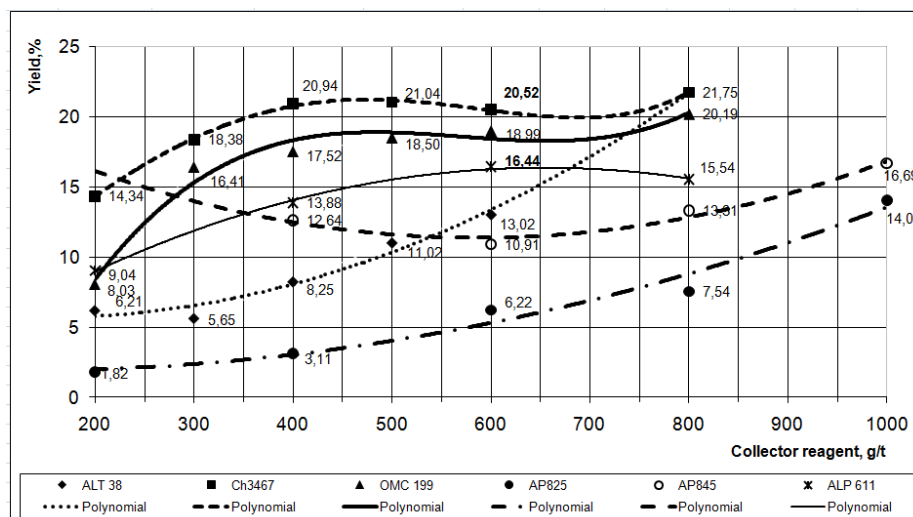


Fig. 6. The barite concentrate yield depending on different collector reagent dosages

The results show that the highest yield has been achieved by using Chemopen 3467 reagent. In Figure 3 we can see that barite concentrate yield does not increase after collector reagent dosage reaches 550 g/t for most of the collector reagents.

The BaSO_4 content in flotation concentrate depending on different collector reagent dosages is shown in Figure 7.

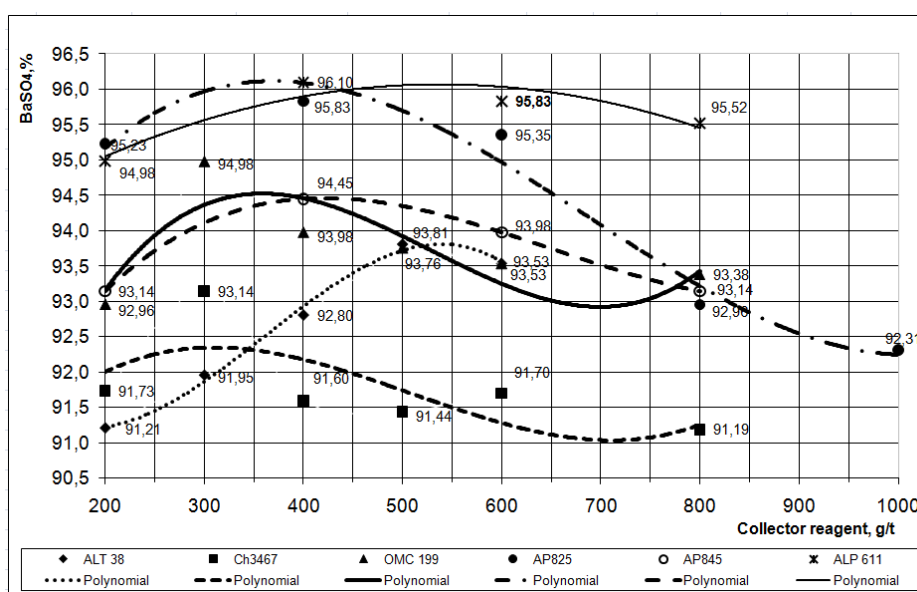


Fig. 7. The BaSO_4 content in flotation concentrate as a function of different collector reagent dosages

The highest BaSO_4 content in concentrate is obtained using collector reagent ALP 611, which is equivalent to BaSO_4 content in class „A” concentrates. Figure 4 illustrates that BaSO_4 content in barite concentrate does not increase further after collector reagent dosages reaches 450-550 g/t.

The influence of different collector reagent dosages on BaSO_4 recovery in the concentrate is presented in Figure 8.

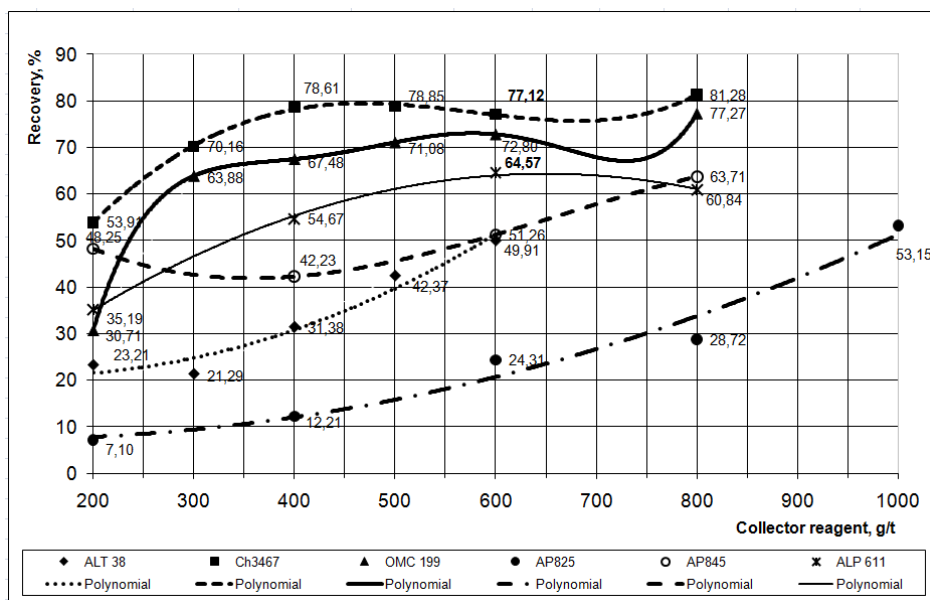


Fig. 8. BaSO_4 recovery in the concentrate presented as function of the different collector reagent dosages

The results from the BaSO_4 recovery in concentrate are also equivalent to industrial data for „Raw tailings” processing including three cleaner operations. The collector reagent ALP 611 at 600 g/t dosage reaches more than 64% recovery. The highest recovery that has been registered has been more than 70 % and it was achieved when using OMC 199 and Chemopen 3467 reagents, but in these two cases the BaSO_4 content in barite concentrate is low.

Table 3 summarizes results from the selected flotation tests using different collector reagent at determined reagent regime.

As obvious from those results in Table 1, the highest yield is achieved by using Chemopen 3467 reagent – 20.52 % as well as the highest BaSO_4 recovery in concentrate – 77.12 % at collector reagent dosage 600 g/t, however, it has very high iron content – 3.51%.

We can definitely state that the highest BaSO_4 content – 95.83 % (which classifies it as „A” barite concentrate) and low iron content – 0.87 % is obtained by ALP 611 collector reagent at dosage 600 g/t. In addition to these results the good barite concentrate yield 16.44 % and good BaSO_4 recovery – 64.57 % make ALP 611 the most productive collector reagent for "Black tailings" flotation from all six test reagents.

Table 3. Results from flotation tests using different collector reagent with determined reagent regime

Type of collector	Collector, g/t	Frother Dehydrol 04, g/t	Depressant Sodium silicate, g/t	Product	Yield, %	Content, %		Recovery, %	
						Fe	BaSO ₄	Fe	BaSO ₄
OMC 199	Rougher-600	Rougher-30	Rougher-1640	Barite con.	18.99	1.99	93.53	1.25	72.80
	I Cleaner-100			Total tailings	81.01	36.51	-	98.75	27.2
	II Cleaner-100			Flot. feed	100	29.95	24.40	100	100
AP 825	Rougher-600		Rougher-2000	Barite con.	6.22	1.24	95.35	0.27	24.31
	I Cleaner-100		I Cleaner-400	Total tailings	93.78	31.85	-	99.73	75.69
	II Cleaner-100		II Cleaner-200	Flot. feed	100	29.95	24.40	100	100
AP 845	Rougher-600	Rougher-7.5	Rougher-2000	Barite con.	10.91	1.64	94.45	0.60	42.23
	I Cleaner-100		I Cleaner-400	Total tailings	89.09	33.42	-	99.40	57.77
	II Cleaner-50		II Cleaner-200	Flot. feed	100	29.95	24.40	100	100
ALT 38	Rougher-500		Rougher-1640	Barite con.	11.02	1.96	93.81	0.72	42.37
	I Cleaner-100			Total tailings	88.98	33.42	-	99.28	57.63
	II Cleaner-50			Flot. feed	100	29.95	24.40	100	100
Chem 3647	Rougher-600		Rougher-1640	Barite con.	20.52	3.51	91.70	2.40	77.12
	I Cleaner-100			Total tailings	79.48	36.78	-	97.60	22.88
	II Cleaner-50			Flot. feed	100	29.95	24.40	100	100
ALP 611	Rougher-600	Rougher-15	Rougher-2000	Barite con.	16.44	0.87	95.83	0.47	64.57
	I Cleaner-50			Total tailings	83.56	35.67	-	99.53	35.43
				Flot. feed	100	29.95	24.40	100	100

3.2.2. Study of the influence of collector mixtures dosages on floatability of "black tailings" non-magnetic fraction

- Collector mixture of OMC 199 and test reagents at ratio 3:1 or 1:1

The dependence of barite concentrate yield on collector reagent mixtures dosages is presented in Figure 6.

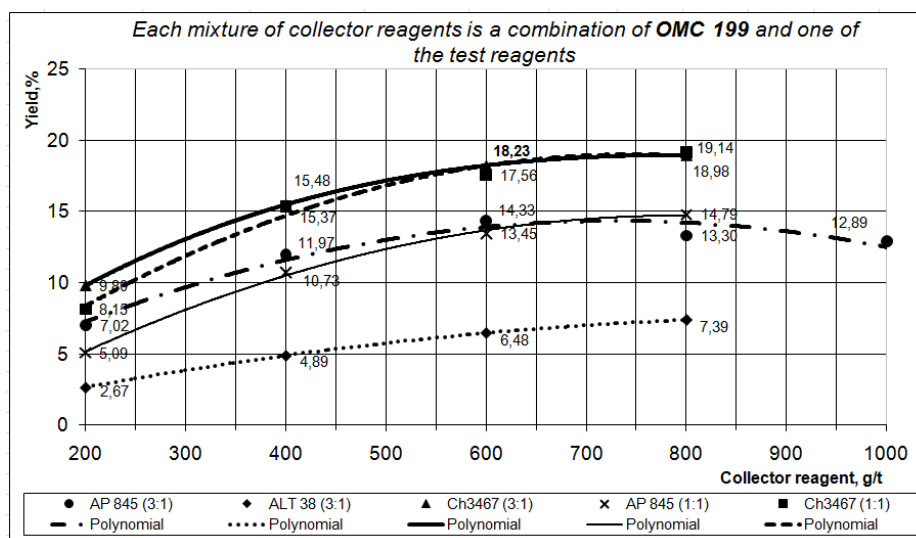


Fig. 9. Barite concentrate yield as function of different collector reagent mixtures dosages

The mixture of OMC 199 and Chemopen 3467 at ratio 3:1 and 1:1 is the most effective with regard to concentrate yield. The yield reaches more than 18%, which is higher than the yields achieved using one reagent. The rest of the mixtures are not effective compared with this one. Figure 9 clearly shows that barite concentrate yield increase is related to the collector reagent dosage increase.

Figure 10 presents the BaSO_4 content in barite concentrate depending on different collector reagent mixtures dosages.

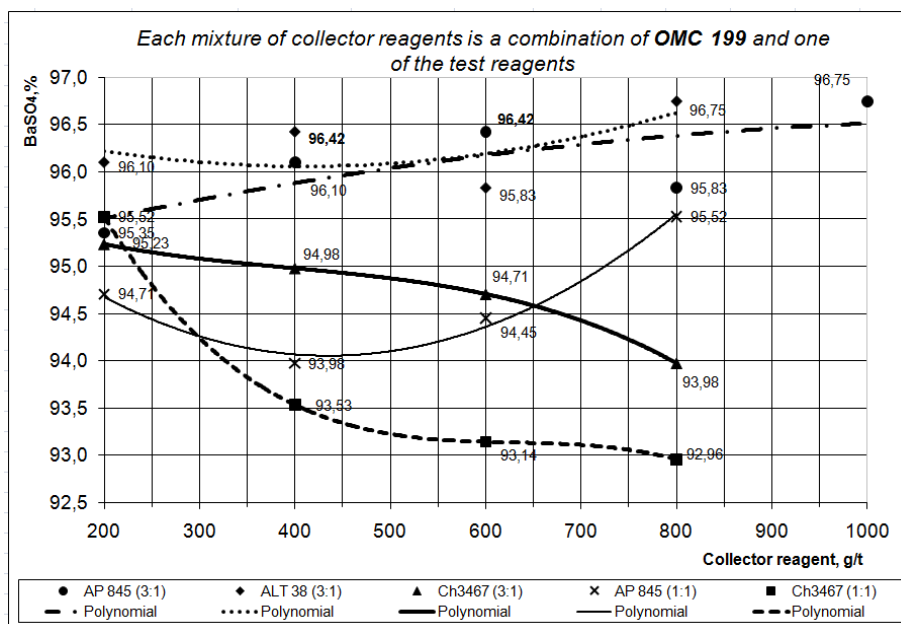


Fig. 10. The BaSO_4 content in flotation concentrate as function of different collector reagent mixtures dosages

The highest quality concentrates are achieved using mixtures of OMC 199 with AP 845 (3:1) and ALT 38 (3:1) – more than 96 %. These mixtures result in the lowest Fe content in barite concentrate:

- OMC 199 : AP 845 (3:1) – 0.82 % Fe.
- OMC 199 : ALT 38 (3:1) – 0.70% Fe.

The dependence of BaSO_4 recovery in barite concentrate on different collector reagent mixtures dosages is presented in Figure 11.

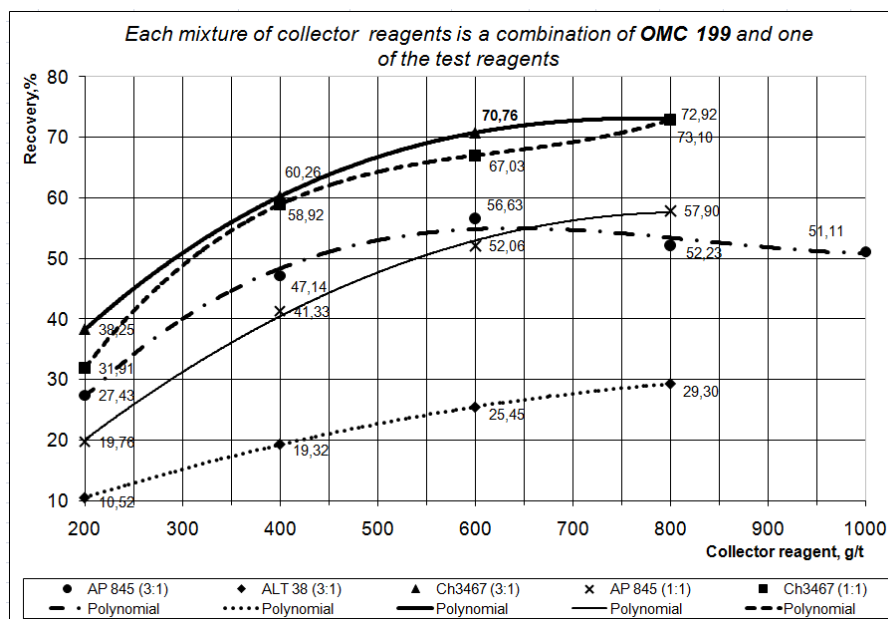


Fig. 11. The dependence of BaSO_4 recovery in barite concentrate on different collector reagent mixtures dosages

The mixture of OMC 199 and ALT 38 (3:1) is highly ineffective. It results in very low yield due to very bad foam configuration during the test. The highest recovery has been achieved using combination of OMC 199 and Chemopen 3467 (3:1) – more than 70 % at dosage 600 g/t. In this case a third cleaner operation is necessary to obtain high quality barite concentrate.

Table 4 summarizes the results from the selected flotation tests with different of collector reagent mixtures of OMC 199 and test reagents, at ratio 3:1 and 1:1 at determined reagent regime. This table includes flotation tests results from mixture of OMC 199 : Chemopen 3467 (3:1) including third cleaner operation at determined reagent regime.

Table 4. Flotation tests results from different mixtures of OMC 199 and test reagents at determined reagent regime

Type of collector	Collector, g/t	Frother Dehydrol 04, g/t	Depressant Sodium silicate, g/t	Product	Yield, %	Content, %		Recovery, %	
						Fe	BaSO ₄	Fe	BaSO ₄
Mix: OMC 199 and AP 845 (3:1)	Rougher-600	Rougher-10	Rougher-2000	Barite con.	14.33	0.82	96.42	0.41	56.63
	I Cleaner-100		I Cleaner-400	Total tailings	85.67	34.82	-	99.59	43.37
	II Cleaner-50		II Cleaner-200	Flot. feed	100	29.95	24.40	100	100
Mix: OMC 199 and ALT 38 (3:1)	Rougher-600		Rougher-2000	Barite con.	7.39	0.70	96.75	0.16	29.30
	I Cleaner-50			Total tailings	92.61	32.29	-	99.84	70.7
				Flot. feed	100	29.95	24.40	100	100
Mix: OMC 199 and Chem 3467 (3:1)	Rougher-600	Rougher-15	Rougher-2000	Barite con.	18.23	1.52	94.71	0.92	70.76
	I Cleaner-50			Total tailings	81.77	36.29	-	99.08	29.24
				Flot. feed	100	29.95	24.40	100	100
Mix: OMC 199 and Chem 3467 (3:1) + III Cleaner	Rougher-600	Rougher-18	Rougher-2000	Barite con.	16.17	1.17	95.52	0.63	63.30
	I Cleaner-50		I Cleaner-200	Total tailings	83.83	35.50	-	99.37	36.7
			II Cleaner-200	Flot. feed	100	29.95	24.40	100	100
			III Cleaner-200						
Mix: OMC 199 and AP 845 (1:1)	Rougher-800	Rougher-15	Rougher-2000	Barite con.	14.79	1.17	95.52	0.57	57.90
	I Cleaner-50			Total tailings	85.21	34.95	-	99.43	42.1
				Flot. feed	100	29.95	24.40	100	100
Mix: OMC 199 and Chem	Rougher-600	Rougher-15	Rougher-2000	Barite con.	17.56	2.34	93.14	1.36	67.03
	I Cleaner-50			Total tailings	82.44	35.84	-	98.64	32.97

3467 (1:1)				Flot. feed	100	29.95	24.40	100	100
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Based on Table 4 results, it is obvious that the most effective mixture with regard to the concentrate yield is OMC 199 : Chemopen 3467 (3:1). The concentrate yield is more than 18 % and BaSO₄ recovery in barite concentrate is more than 70 %. The BaSO₄ content in barite concentrate using this combination is lower compared with content obtained by the combination of OMC 199 : ALT 38 (3:1), but it is exceptionally ineffective due to the very low yield and low recovery.

In order to obtain high quality barite concentrate using OMC 199 : Chemopen 3467 combination (3:1), 4 additional flotation tests have been carried out including third cleaner operation which are shown in Table 4.

Figure 12 presents the comparative results from the flotation tests using two cleaner operation and three cleaner operation at equal dosage of collector reagent (OMC 199 : Ch 3467 (3 : 1) mixture – 600g/t.

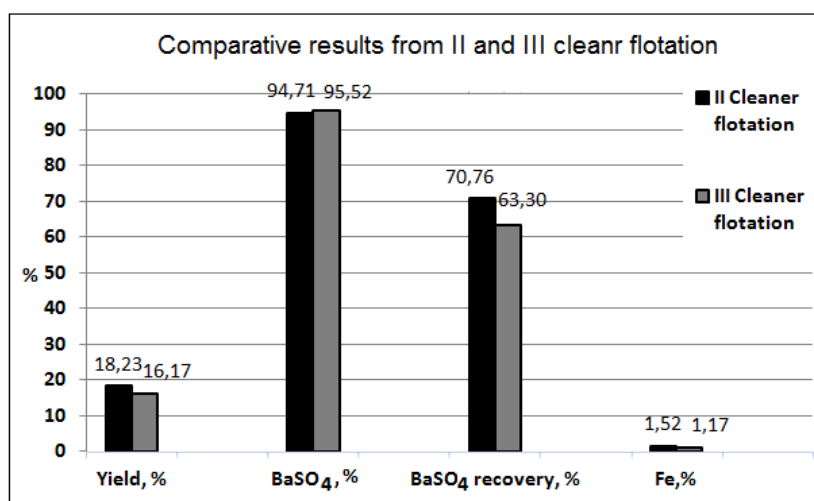


Fig. 12. Comparative results from II and III cleaner flotation at collector reagent dosage 600 g/t

As Figure 12 shows, the third cleaner operation enhances the BaSO₄ content in the concentrate. However, BaSO₄ yield and recovery are lower compared with the yield and recovery when only two cleaner operations are applied. Third cleaner operation promotes for obtaining higher quality barite concentrate for the sake of lower BaSO₄ yield and recovery. Based on the results we can conclude that the combination of collector reagents OMC 199 : Ch 3467 (3 : 1) can be used for the production of barite concentrate class „B”.

- Collector mixture of ALP 611 and test reagents at ratio 3:1 or 1:1

Figure 13 presents the functional dependence of the barite concentrate yield on the different collector reagent mixtures dosages.

Based on the results we can definitely conclude that the combination of ALP 611 and OMC 199 is most effective with regard to concentrate yield. The concentrate yield at ratio 3:1 is over 16%. The rest of the combinations are not effective.

Figure 14 shows the BaSO₄ content in the concentrate depending on the different collector reagents mixtures dosages.

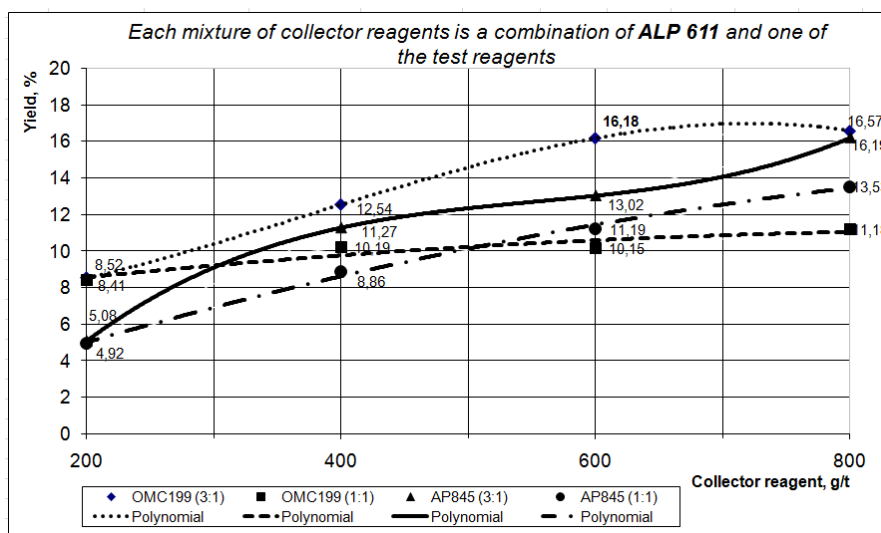


Fig. 13. Barite concentrate yield as function of different collector reagent mixtures dosages

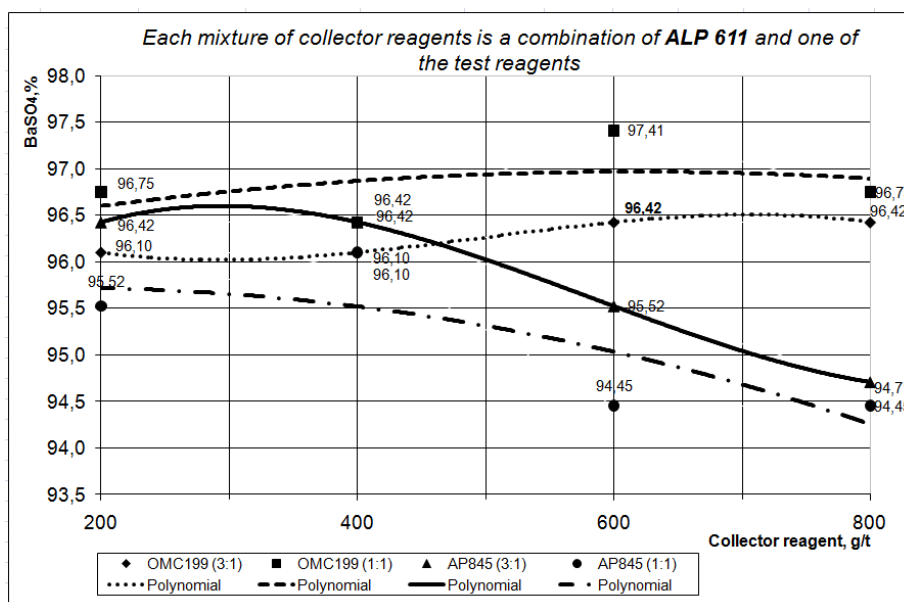


Fig. 14. BaSO₄ content in the concentrate depending on the different collector reagents mixtures dosages

The tested reagents mixtures are effective with regard to the BaSO₄ content. Most of the final products from the tests are high quality concentrate with high BaSO₄ content in the concentrate - over 94 % and a third cleaner operation was not necessary.

Figure 15 presents the dependence of BaSO₄ recovery in the concentrate on the different collector reagents mixtures dosages.

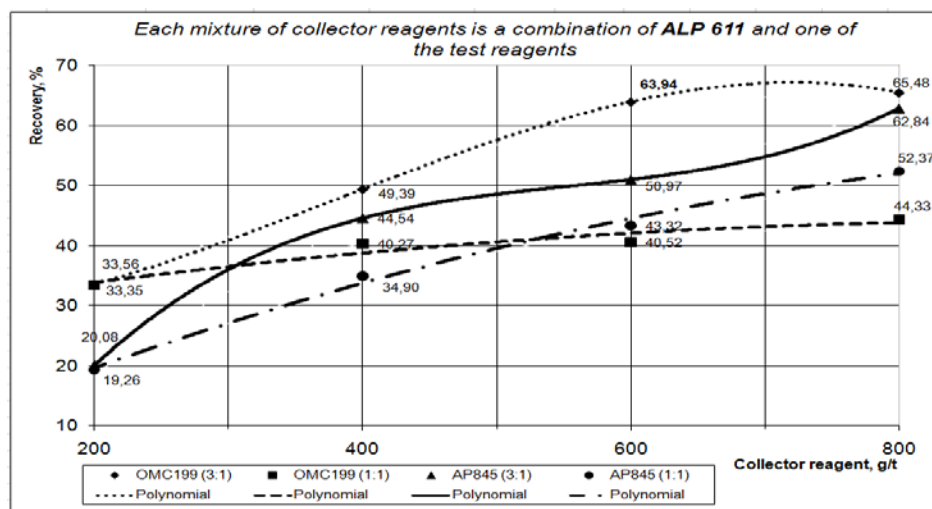


Fig 15. Functional dependence of BaSO_4 recovery in the concentrate on the different collector reagents mixtures dosages

The results clearly show the high effectiveness of the combination ALP 611 and OMC 199 at ratio 3:1. At mixture dosage 600 g/t the recovery is over 63 %.

Table 5 contains the results from the selected flotation tests with collector reagent mixture ALP 611 and the collector reagents that are subject of study at ratio 3:1 or 1:1 at a determined reagent regime.

From the results in Table 5 it is obvious that ALP 611: OMC 199 combination at ratio (3:1) is the most effective one as the concentrate yield reaches 16.18 %, BaSO_4 content – 96.42 % and BaSO_4 recovery in barite concentrate – 63.94 %. The rest of the mixtures reach very poor recovery, due to low yield. The Fe content in the barite concentrate is 0.82 %. The quality characteristics of barite concentrate produced with the help of collector reagent mixture ALP 611: OMC 199 (3:1), meet the class “A” standards.

Table 5. Results from flotation tests with collector reagent mixture of ALP 611 and the collector reagents subjects of study at a determined reagent regime

Type of collector	Collector, g/t	Frother Dehydrol 04, g/t	Depressant Sodium silicate, g/t	Product	Yield, %	Content, %		Recovery, %	
						Fe	BaSO ₄	Fe	BaSO ₄
Mix: ALP 611 and OMC 199 (3:1)	Rougher-600 I Cleaner-50	Rougher-15	Rougher-2000	Barite con.	16.18	0.82	96.42	0.44	63.94
				Total tailings	83.82	35.57	-	99.56	36.06
				Flot. feed	100	29.95	24.40	100	100
Mix: ALP 611 and OMC 199 (1:1)	Rougher-600 I Cleaner-50	Rougher-15	Rougher-2000	Barite con.	10.15	0.47	97.41	0.15	40.52
				Total tailings	89.85	33.28	-	99.85	59.48
				Flot. feed	100	29.95	24.40	100	100
Mix: ALP 611 and AP 845 (3:1)	Rougher-400 I Cleaner-50	Rougher-15	Rougher-2000	Barite con.	11.27	0.82	96.42	0.31	44.54
				Total tailings	88.73	33.65	-	99.69	55.46
				Flot. feed	100	29.95	24.40	100	100
Mix: ALP 611 and AP 845 (3:1)	Rougher-600 I Cleaner-50	Rougher-15	Rougher-2000	Barite con.	11.19	1.64	94.45	0.60	43.32
				Total tailings	88.81	33.52	-	99.40	56.68
				Flot. feed	100	29.95	24.40	100	100

4. CONCLUSIONS

- The grindability study shows that the two tailing types - "Black tailings" and „Raw tailings” reach close values of the particle size content “-0.071 mm” which allow good mineral liberation.
- Open bench-scale flotation tests show that the tailings from Kremikovtzi ore processing including magnetizing roasting "Black tailings" could be beneficiated by flotation with suitable selection of reagents.
- The production of high quality barite concentrate with BaSO₄ content over 95 % and Fe – (0.82 – 1.52%), at BaSO₄ recovery over 64 % could be achieved by using collector reagent ALP 611 or reagent mixture OMC 199 with Chemopen 3467 and ALP 611 with OMC 199 at ratio 3 : 1 and collector reagent dosage 600 g/t. The quality characteristics of the produced barite concentrate meet the international standards of class “A” and “B”.

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