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Flotation of barite from complex iron ore

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ABSTRACT

The present contribution is aimed at the production of a high-grade barite concentrate from complex iron ores of ore-deposit Kremikovtzi, Bulgaria. The ores consisting mainly of limonite, hematite and siderite have been beneficiated by high intensity electromagnetic wet separation on magnetic separator type Jones DP 317. Barite flotation has been succeeded from non-magnetic fraction merged with ground barite raw materials. The collecting flotation agents OMC 199 and AERO 845 (2:1 ratio) at the total dosage rate of 400-450 g/t have been applied. The frother OrePrep F 501 consumption has been 10-15 g/t. Water glass has been applied as a silica depressant at the application rate of 4-4.5 kg/t. Annual output of flotation barite concentrate reach 120 000 tons. Of this quantity 75 wt.% are exported in bulk with total assay of $BaSO_4$ and $SrSO_4$ 97-98 wt.% and 8 wt.% moisture. The rest part is dried, ground and bagged. The quality corresponds to OCMA (Oil Companies Material Association) /API (American Petroleum Institute) requirements.

Keywords *: Industrial minerals, Barite concentrate, Magnetic separation, Froth flotation*

INTRODUCTION

The production of flotation barite concentrate from mined complex iron ores and raw barite materials at Kremikovtzi mine are subjects of examination in the present paper. The beneficiation plant was put into operation in 1964 and was fitted out with magnetizing roasting kilns, low intensity magnetic separators, flotation cells, concentration tables and equipment for dewatering and drying of concentrates. The implemented technology was not environmentally friendly[1], gave rise to problems, did not provided a high recovery for barite (only up to 35 wt.%), could not output high-grade (83.3-93.5 wt.%) barite concentrate[2]. The

recovery of barite from the ores of the ore-deposit Kremikovtzi was enhanced after performing of two Humbolt Wedag high intensity magnetic separators type Jones DP 317 and by the usage of more effective flotation reagents since 1990.

CHARACTERIZATION OF RAW MATERIALS IN ORE-DEPOSIT KREMIKOVTZI

The mineralogical composition of the ores from Kremikovtzi ore-deposit is very complex. It includes limonite, siderite, hematite, barite and some other mineral bearers of manganese, lead, and barium and less copper[3]. Data relating the contents of main components in the various ores during exploration of industrial types of ores are presented in Table 1. The hematite and lead ores contain the lowest quantities of barium sulfate.

According to M. Benov[4] reserves of barite in the ore-deposit are 58.4 Mt., out of them 28.8 Mt are in barite raw material. Moreover, 4.3 Mt barite raw materials with $BaSO_4$ content of 28-45 wt.% are in stacks arranged during the development of the ore-deposit. Several mineralogical and geochemical certain features in siderite were observed penetrating into the minefield[5, 6]. More than 90 wt.% from them are siderite, barite and quartz. Data provided in consequence from the exploration and exploitation of Kremikovtzi ore-deposit show that the barite is the most widespread non-metalliferous mineral. It can be met in the form of cores and veins and almost everywhere, barite is merged intimately with siderite and limonite ores. The other barium containing mineral viterite is less abundant.

Table 1 : Main ingredients in various types ores hosting at the ore-deposit Kremikovtzi

Type ore	Assay, wt.%					
	Fe	$BaSO_4$	Mn	Pb	SiO_2	CaO
Hematite	48.2	9.9	1.1	0.21	3.84	3.18
Siderite	21.6	17.0	5.2	0.75	8.86	5.57
Limonite	31.5	18.9	7.7	0.64	6.50	3.08
Barite raw material	12.4	30.4	2.5	1.21	9.6	15.9
Lead	9.5	8.2	2.6	1.20	4.3	26.1

MARKETS, QUALITY AND PRICES OF BARITE

The flotation barite concentrate produced from Kremikovtzi ore-deposit was exported to former USSR, Romania, Hungary and Albania in a bulk. Recently, a new market having strong requirements to the product quality has been devel-

oped. The quality is determined depending on the barite application[7] by following characteristics:

- Physical: density, whiteness, particles size;
- Chemical: max. content (wt.%) of Fe_2O_3, Al_2O_3, SiO_2 as quartz, CaF_2, TiO_2, sulfides, soluble alkalis, moisture and heavy metals (in ppm).

According to Industrial Minerals[8], midyear (1998) international prices were as follows:

- API, lump, c.i.f. (cost, insurance, and freight) [US] Gulf Coast, Chinese, $50 to $52, Indian, $52 to $54, Moroccan, $52 to $54;
- Unground, OCMA/API, bulk, specific gravity 4.2, f.o.b. (free on board) Morocco, $42 to $44 per ton;
- Ground, bagged, specific gravity 4.22, f.o.b. Morocco, $75 to $85 per ton
- Ground, OCMA/API, big bags (1.5 tons) f.o.b. South Turkey, $64 to $68 per ton;
- Ground, OCMA, bulk, delivered Aberdeen, United Kingdom [UK], $84.14 to $91.45 per ton, delivered Great Yarmouth [UK], $94.44 to $108.08 per ton;
- Micronised, off white minimum 99% less than 20 micrometers delivered UK, $232.78 to $249.40 per ton
- Ground, white, paint grade, 96-98 wt.% $BaSO_4$, 350 mesh, 1-5 tons delivered UK, $324 to $365.79 per ton.

TECHNOLOGY FOR PRODUCTION OF BARITE CONCENTRATE

Technological scheme for production of barite concentrate from ferrous ores and raw barite materials in Kremikovtzi ore-deposit is shown in Fig. 1. This flow-sheet was developed based on investigations carried out in Bulgaria and in other countries[1, 9-20]. A version has been chosen from all possible technological schemes containing optimal particles size, 100 wt.% -0.5 mm for high gradient magnetic separation.

The ferrous minerals are recovered first of all according to the selected scheme. The opposite sequence is applied for the barite raw materials. The barite is recovered prior at the optimal particle size for its flotation. The development of a technological process for beneficiation of barite raw materials is under way. The introduction of high intensity magnetic separation for recovery of ferrous minerals from the residue of barite flotation is conceived. The high gradient magnetic separation is carried out by means of two separators type Jones DP 317 and barite flotation by means of pneumatic-mechanical flotation machines, type Denver D-R.

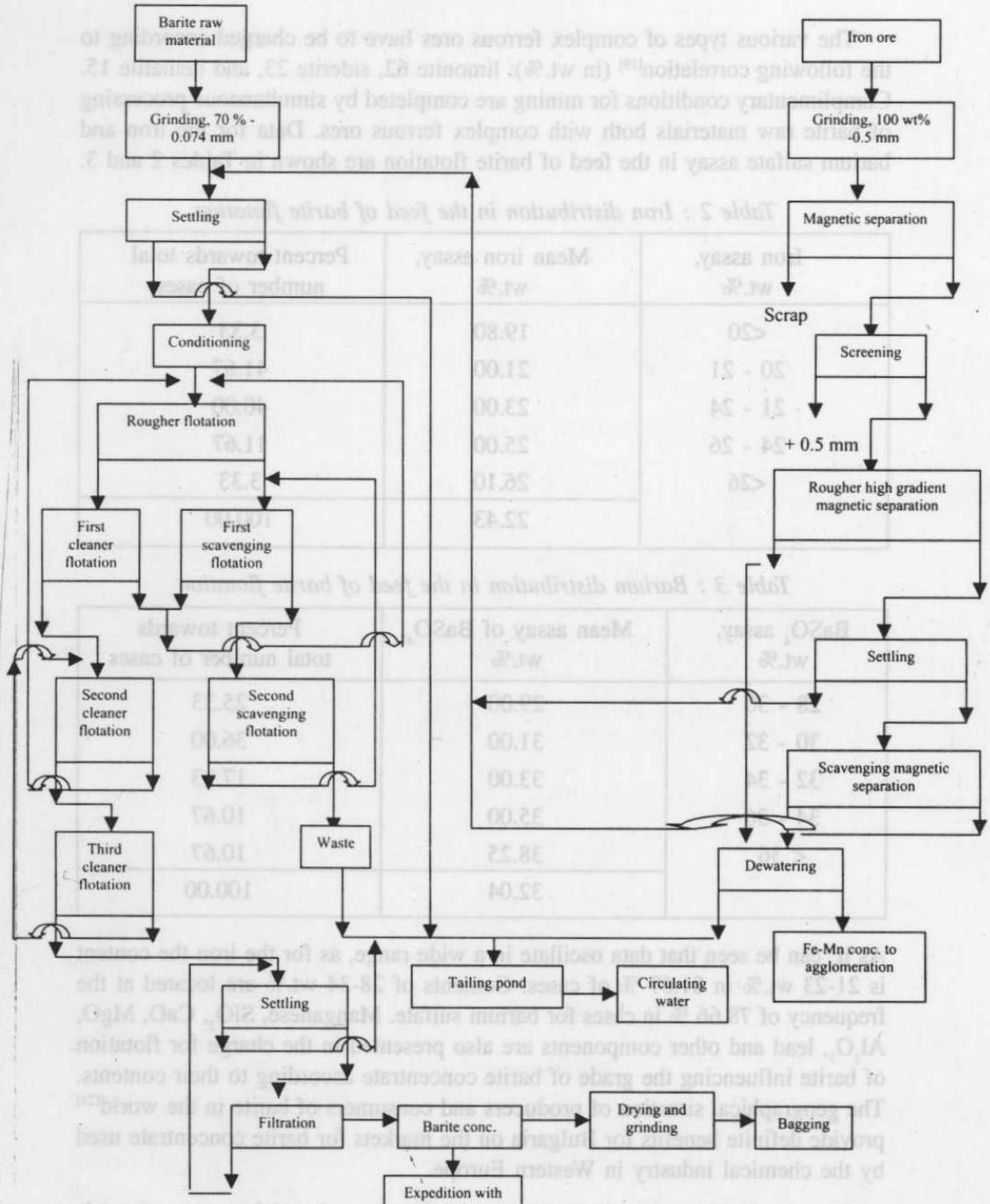

Fig. 1 : Technological flow sheet for barite concentrate production

The various types of complex ferrous ores have to be charged according to the following correlation[19] (in wt.%): limonite 62, siderite 23, and hematite 15. Complimentary conditions for mining are completed by simultaneous processing of barite raw materials both with complex ferrous ores. Data for the iron and barium sulfate assay in the feed of barite flotation are shown in Tables 2 and 3.

Table 2 : Iron distribution in the feed of barite flotation

Iron assay, wt.%	Mean iron assay, wt.%	Percent towards total number of cases
<20	19.80	3.33
20 - 21	21.00	41.67
21 - 24	23.00	40.00
24 - 26	25.00	11.67
<26	26.10	3.33
	22.43	100.00

Table 3 : Barium distribution in the feed of barite flotation

$BaSO_4$ assay, wt.%	Mean assay of $BaSO_4$, wt.%	Percent towards total number of cases
28 - 30	29.00	25.33
30 - 32	31.00	36.00
32 - 34	33.00	17.33
34 - 36	35.00	10.67
< 36	38.25	10.67
	32.04	100.00

As it can be seen that data oscillate in a wide range, as for the iron the content is 21-23 wt.% in 81.67 % of cases. Contents of 28-34 wt.% are located at the frequency of 78.66 % in cases for barium sulfate. Manganese, SiO_2, CaO, MgO, Al_2O_3, lead and other components are also presented in the charge for flotation of barite influencing the grade of barite concentrate according to their contents. The geographical situation of producers and consumers of barite in the world[21] provide definite benefits for Bulgaria on the markets for barite concentrate used by the chemical industry in Western Europe.

Data for $BaSO_4$ content in the barite concentrate produced from raw materials with mean iron assay of 22.43 wt.% and $BaSO_4$ 32.04 wt.% (see Tables 2 and 3) are presented in Table 4. The content of $BaSO_4$ in the concentrate is higher

than 97 wt.% in 53.09 % of the cases and lower than 95 wt.% in 1.23 % of the cases. The mean is 96.88 wt.%. There is not detected any content of CaF_2 in the concentrate. The content of $Ba(Sr)SO_4$ in the high-grade barite concentrate has to achieve 97 wt.% min., according to the requirements of the Solvay Barium Strontium Group GmbH. The content of $SrSO_4$ in the produced barite concentrates quantified 1.4 wt.%.

Table 4 : Barium distribution in barite concentrate

$BasSO_4$ in concentrate, wt.%	Mean of $BasSO_4$ in concentrate, wt.%	Percent towards total number of cases
95	94.89	1.23
95 - 97	96.59	45.68
> 97	97.17	53.09
	96.88	100.00

The production of a high grade barite concentrate is carried out the following conditions: particle size 65-70 wt.% -0.074 mm after grinding; solid phase in under rougher barite flotation 34 %; temperature of the pulp in the rougher barite flotation 26-30°C; pH of the pulp in the rougher barite flotation 8-9. The reagents dosage is as follows: collecting agent OMC 199 and AERO 845 in the ratio 2:1, at total consumption rate of 400-450 g/t. Feeding point: conditioning before rougher flotation, first and second scavenging and in case of need first cleaner flotation. Frother: OrePrep F501; dosage 10-15 g/t during main flotation and in case of need in the first cleaner flotation. Depressant: water glass (Na_2SiO_3), total dosage 4-4.5 kg/t. Feeding point: conditioning before rougher flotation and in the first, second and third cleaner flotations.

Information concerning quality of barite concentrate produed according to the considered technological regulations is shown in Table 5. The requirements of the barite concentrate for chemical industry[5] are also given in this table for comparison. The Fe_2O_3 content is higher but in return for this SiO_2 is many times lower than admissible.

The high grade barite concentrate can be produced only by the using collector OMC 199 or the usage of collectors AERO 840 and 845 in the ratio1:1. The frother OrePrep F501 is used in the first case and the AEROFROTH 65 and 70 in the second case. Water glass is added as a depressant in both cases.

The production of barite concentrate according to the OCMA and API requirements is not accompanied by troublesome difficulties. In this case part of reagents OMC 199 and AERO 840 and 845 and substituted by potassium oleate.

The filtered barite concentrate is dried, ground and bagged in bags 25 and 50 kg or in1 and 1.5 tons big bags. The recently assembled plant type POAMIL PM 16 can be used in full capacity, due to the shortage of markets for concentrate with quality characteristics according to the requirements of OCMA/API.

Table 5 : Chemical composition of the high-grade flotation concentrate and requirements of chemical industry

Components	Assay, wt.%	
	Concentrate	Requirements[51]
$BaSO_4$	97.08	<95.00
SiO_2	0.44	<2.50
Fe_2O_3	0.60	<0.15
CaO	0.44	0.05 —
MnO	0.90	—
Pb	0.07	—
CaF_2	—	<1.00

ENVIRONMENTAL PROTECTION

Wastewater from the power plant is used in the ore dressing plant. The applied organic reagents in the flotation are biodegradable[18,22,23]. Wastewater settling is carried out in the tailing pond. A part of purified water is recycled in flotation plant. Water from agglomeration plant is also discharged to the tailing pond. The surplus water is used for industrial water supply of metallurgical works. The effectiveness of dust collecting equipment at drying, grinding and packing installation reaches 99.99 %.

CONCLUSION

The high grade flotation concentrate containing 77-98 wt.% $Ba(Sr)SO_4$ is produced from complex ferrous ores containing hematite, siderite, barite and other minerals aimed for chemical industry. The production of barite concentrate with quality according to the requirements of OCMA/API is limited because of shortage of suitable markets.

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