Mineral characterization and processing of barite from contendas of sincorá - Ba - Brazil

Caracterização e processamento mineral da barita de contendas do sicorá - Bahia - Brazil

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ABSTRACT

Barite is a barium sulphate mineral ($BaSO_4$) with high specific weight (4.5 g/cm^3). It is specially used as a drilling fluid in oil and gas exploration, to suppress high formation pressures and to prevent blowouts.

Two samples of Contendas of Sincorá – Bahia State – Brazil, were studied in order to develop a mineral processing route to recover barite. The mineral characterization (X-ray fluorescence and X-ray diffractometry analysis) revealed that the samples are composed respectively of 55 and 75% of barite; however, their SiO_2 contents were considered high, varying from 40 to 25% (weight %).

A gravity separation process was proposed due to the large difference of specific weights between quartz and barite with values of 2.65 and 4.5, respectively. The sinking and floating tests were performed on the ore sieved at screen of 6.35, 1.19 and 0.149 mm. Bromoform was used as a heavy liquid (2.89 g mL^{-1}). The results showed that 90% of the material was concentrated in the sunk product, suggesting that quartz is still associated to barite, probably by liberation problems.

Therefore, the samples were crushed to <0.149 mm (100# Tyler) and submitted to froth flotation tests. The reverse flotation of quartz did not reveal good results since quartz was still associated to barite in the depressed product. Thus, a direct froth flotation of barite was carried out and the results showed an improvement of the barite concentrate. The metallurgical recoveries obtained were 64 and 76% (weight percent) with 82% and 85% of barite content.

Keywords: process mineralogy, barite, froth flotation

RESUMO

A barita é um sulfato de bário ($BaSO_4$) com alta densidade (4.5 g/cm^3). É usada como fluido de perfuração na exploração de gás, pois impede a formação de altas pressões, que poderiam acarretar explosões.

Duas amostras oriundas do município de Contendas of Sincorá, localizado no estado da Bahia – Brazil, foram estudadas com o objetivo

determinar uma rota de processamento mineral a ser implantada neste depósito. A caracterização mineral, realizada através de análises químicas por fluorescência de raios e mineralógicas por difratometria de raios X revelaram que as amostras são compostas por 55 a 75% em massa de barita e o quartzo, considerado ganga, pode compor de 40 a 25% da amostra.

A separação gravítica foi considerada, em razão da diferença de densidade entre estes dois minerais (quartzo- 2.65 e barita- 4.5). Ensaios de afunda-flutua foram realizados no minério retido nas malhas de 6,35; 1,19 e 0,149 mm, usando bromofórmio como líquido denso (2.89 g mL^{-1}). Os resultados mostraram que 90% do material foi concentrado no produto afundado, sugerindo que o quartzo afundava juntamente com a barita, provavelmente por problemas de liberação.

Por fim, as amostras foram moídas abaixo de 0,149 mm (100# Tyler) e realizaram-se ensaios de flotação. A flotação reversa não mostrou bons resultados, o quartzo era arrastado juntamente com a barita para o produto deprimido. A flotação direta da barita foi testada e os novos resultados mostraram melhor seletividade no concentrado de barita. As recuperações metalúrgicas alcançadas foram de 64 e 76% (% em massa) com teores de 82% e 85% de barita.

Palavras chaves: caracterização mineral, barita e flotação.

INTRODUCTION

The main barite use is to control slurry density in drilling for petroleum exploitation. Nearly 90% of the world barite resources is intended to petroleum exploitation. The Brazilian production of barite refers to only 0.04% of the world production [1].

Contendas of Sincorá is a small city in the south-west part of Bahia State. The deposit was firstly studied by CBPM – Companhia Baiana de Pesquisa Mineral, a governmental organism of the Bahia State, responsible to conduct geological researches in the Bahia State. The preliminary studies revealed that the deposit has nearly 200 thousand tons of resources [2]. The mineralization is located in the volcano-sedimentary complex of Contendas-Mirante [3].

MATERIALS AND METHODS

In this study, the bulk samples were characterized in LCT laboratory at Sao Paulo University – EPUSP. The chemical analysis was performed by X-ray fluorescence (XRF) from Bruker (S8 – Tiger model) and the minerals were identified by randomly oriented X-ray powder diffraction. X-ray diffraction (XRD) patterns were recorded on a Bruker AXS D8 Endeavor diffractometer (Cu Kα radiation - 40 kV, 40 mA- Lynx eye detector) from 2 to 70° 2θ with steps of 0.02° 2θ and a counting time per step of 115s (converted from scanning mode). The LOI results were obtained from bulk sample heated to 1020°C for 2 hours [4].

For the barite concentration, physical separations by specific weight difference were tested, since barite and quartz specific weights exhibit a large difference. Therefore, a sink-float test was done, using bromoform (ρ=2.89 g/cm^3) to separate particles smaller than 6.35 mm, 1.19 mm and finally <0.149 mm. Under these conditions, quartz should remain within the float product whereas the barite should sink.

Froth flotation experiments were also performed varying promoter reagents, reagents addition, pH, time, impeller speed and others. A summary is exhibited in Table 3.

RESULTS AND DISCUSSIONS

According to chemical analysis (XRF) and X-ray diffraction (XRD), the samples are composed mainly by barite (50 to 60 wt%) and secondarily by quartz (Figure 1 and Table 1). The XRF also suggests the presence of another mineral of strontium, probably celestine ($SrSO_4$). Quartz content varies from 20 to 40% (wt%). The table 1 shows the XRF results for the two samples.

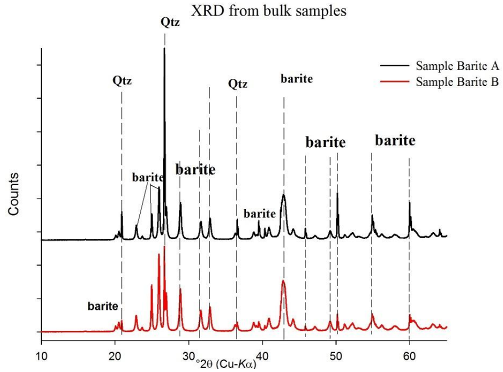

Figure 1 – XRD patterns for the two bulk samples studied.

Once the mineralogical contents were identified, the concentration essays were performed in order to determine the better mineral separation process to be applied to this deposit.

Due to the remarkable specific weight difference for barite (ρ=4.48 g/cm^3) and quartz (ρ=2.65 g/cm^3), the gravity concentration could be a good option. Therefore, a sink-float test on density 2.89 was proposed. The sink/float results are shown in the table 2.

Table 1 - XRF for the bulk samples (Wt%±0.001)

oxides	Barite A	Barite B
Na_2O	0,414	0,479
Al_2O_3	-	0,32
SiO_2	40,1	25,6
SO_3	18,4	23,4
Fe_2O_3	0,098	0,057
SrO	1,25	1,42
BaO	36,5	45,4
PF	2,95	3,18

Table 2 - Sink/float results for the two samples (Wt%) - error ±0,01%.

Size fraction (mm)	float	sink	total	Size fraction (mm)	float	sink	total
sample A				sample B			
+6,35	8,30	91,7	100	+6,35	1,58	98,4	100
-6,35 + 1,19	11,85	88,2	100	-6,35 + 1,19	2,86	97,1	100
-1,19 + 0,149	18,42	81,6	100	-1,19 + 0,149	7,35	92,6	100

The gravity concentration was not able to properly separate quartz from barite, due to probably quartz grains are not released from barite particles. This assumption is confirmed by the higher proportion of float material into the finest particle sizes. Due to the fact that gravity concentration loses efficiency in the finest particle sizes, a froth flotation operation was tried to concentrate this ore.

The reverse flotation of quartz was tested with 250 g of sample crushed to less than 0.149 mm. Experimental froth flotations tests were done on the samples A and B, varying pH and reagents (Flotigam EDA from Clariant and Aerofloat 855 from Cytec) additions as shown in table 3.

Flotigam EDA from Clariant is an eterdiamine partialy etoxilade. Flotigam additions varied from 76 to 130 g/t, with around 250 g of the sample crushed less than 0.149 mm. Many pHs conditions were tested and the reversed froth flotation experiments used an 1.5 min flotation time at 1.200 rpm (rougher) and 1.5 min of flotation at 1.200 rpm (scavenger).

To evaluate the efficiency of the froth flotation experiments, the specific weight of the products was controlled, instead of the chemical control. The measured specific weight determination of the flotation products is easier and faster to obtain than XRF analysis. Moreover, the cost of the chemical analysis is high. On the other hand, the products of specific weight nearly to 4.48 g/cm^3 suggest a high barite concentrate. On the other hand, products around 2.65 g/cm^3 indicate a pure quartz tailling. Thus, the best flotation conditions should result in a barite concentrate with $\rho \approx 4.48$ g/cm^3 and mass recovery of nearly 60% for sample A and 80% for sample B.

However, the barite concentrate did not acquire good results and in order to verify an adequate liberation degree was obtained, scanning electron microscopy observations were performed, as presented in Figure 2. The barite concentrate exhibited few particles of liberated quartz; nevertheless, the quartz concentrate revealed many liberated barite particles together to quartz. It suggests that either the speed of flotation was not adequate or the reagent was not efficient.

Table 3 - Experimental froth flotations (EFF) conditions – error ±0,01%

EFF	Sample	Flotation type	reagent	pH	Dose (g/t)	Float (wt%)	Depressed (wt%)	RPM	specific weight
1	A	reverse	Flotigam	5	76	82.8	17.2	1200	2.99
2	A	reverse	Flotigam	6,5	100	64.1	35.9	1200	4.47
3	A	reverse	Flotigam	7	100	67.0	33.0	1200	4.31
4	A	reverse	Flotigam	7,5	100	63.3	36.7	1200	4.42
5	A	reverse	Flotigam	8	100	62.5	37.5	1200	4.25
6	A	reverse	Flotigam	8,5	76	63.2	36.8	1200	5.01
7	A	reverse	Flotigam	8,5	80	58.3	41.7	1200	4.31
8	A	reverse	Flotigam	8,5	100	59.8	40.2	1200	4.60
9	A	reverse	Flotigam	8,5	110	58.8	41.2	1000	4.58
10	A	reverse	Flotigam	8,5	120	59.8	40.2	1000	4.45
11	A	reverse	Flotigam	8,5	130	60.9	39.1	1000	4.58
12	A	reverse	Flotigam	9	100	56.3	43.7	1000	4.57
13	A	reverse	Flotigam	10	100	46.5	53.5	1000	4.23
14	A	reverse	Flotigam	10,5	100	55.1	44.9	1000	4.37
15	**A**	**direct**	**Aero 855**	**8,5**	**20**	**63.9**	**36.1**	900	**4.48**
1	B	reverse	Flotigam	8,5	60	42.9	57.1	900	4.50
2	B	reverse	Flotigam	8,5	76	34.9	65.1	1000	4.57
2b	B	reverse	Flotigam	8,5	76	33.8	66.2	900	4.57
3	B	reverse	Flotigam	9,5	100	46.1	53.9	900	4.62
4	B	direct	Aero 855	8,5	13	75.6	24.4	900	4.01
5	**B**	**direct**	**Aero 855**	**8,5**	**20**	**76.2**	**23.8**	900	**4.55**
6	B	direct	Aero 855	8,5	30	74.6	25.4	900	4.14

Some experiments were performed twice varying the impeller rotation, however the results did not change as observed in Table 3 EFF2 and 2b for sample B. Thereby, direct froth flotation of barite was tested with Aerofloat 855 of Cytec as shown in Table 3. The results were improved. Acronysm EFF15 stands for sample A and EFF4 to EFF6 for sample B. The collector Aerofloat 855 promoter refers to a petroleum sulphonates. Table 4 shows the chemical results for the best froth flotation experiment for samples A and B where Acronysms EFF15 and EFF5 stand for samples A and B, respectively. The results for the barite concentrate revealed an almost pure barite content with 54.8 and 56.7% of barium. For the compound, the theorical barium content exhibits 58.8% of barium, according to reference [5]. The metallurgical recoveries were 94.2% for sample A and 90.7% for sample B.

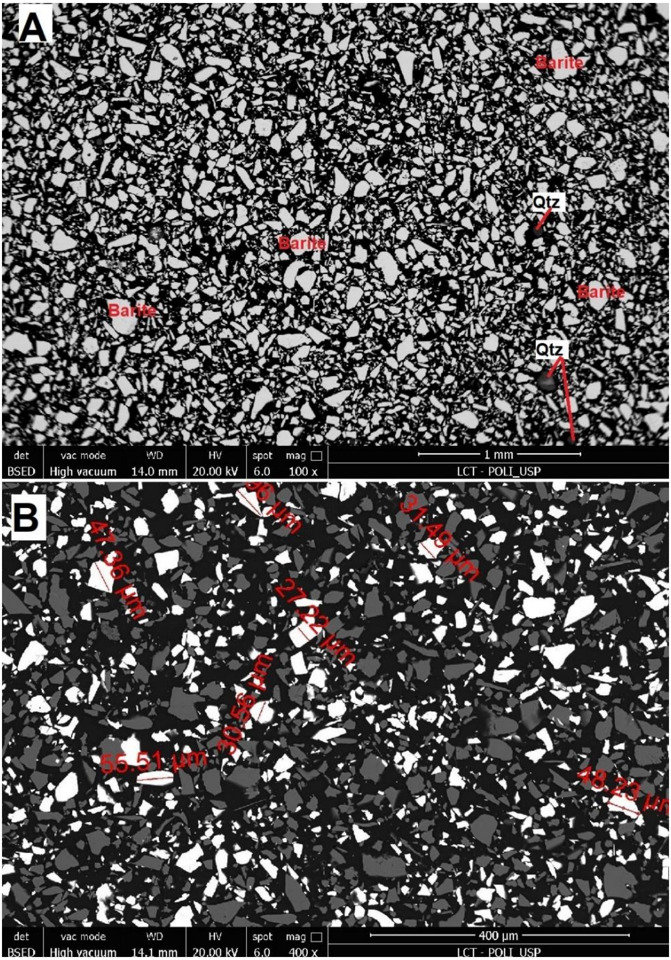

Figure 2 – SEM/BSE image of the reversed froth flotation products. A- barite (write particles) concentrate exhibited few particles of liberated quartz (grey particles). B- the floated concentrate shows liberated barite particles. The particles size are measured by image analysis software from SEM/BSE image.

Table 4 - Chemical results (XRF wt% ±0.001) for the froth flotation products obtained from direct froth flotation by Aerofloat 855

Oxides	Sample A		Sample B	
	conc. Ba	conc. Si	conc.Ba	conc.Si
Al_2O_3	-	0.45	-	0.46
SiO_2	6.36	91.0	5.72	89.7
S	11.2	0.72	11.4	0.85
Fe_2O_3	0.08	0.24	0.08	0.30
SrO	1.67	0.11	1.49	0.11
Ba	54.8	3.59	56.7	4.18
PF	8.43	2.61	6.55	3.03

CONCLUSIONS

The samples are mainly composed of barite and quartz, with small proportions of celestine and clay minerals.

Sink-float separations were tested and they did not exhibit good results, as the liberation degree occurs in the finer size fractions (<0.149 mm).

Many flotations experiments were performed in order to obtain the best separation condition and the most efficient reagents promoters. The concentrate quality was determined by concentrate specific weight measured by pycnometry. A barite concentrate will present a $\rho \approx 4.48$ g/cm^3, whereas a quartz concentrate will exhibit a $\rho \approx 2.65$ g/cm^3.

The best froth flotation condition was a direct flotation of barite with the reagent Aero float 855 (20g/t) in pH of 8.5 with 1.5 min of flotation at 900 rpm (rougher) followed by a 1.5 min of flotation at 900 rpm (scavenger). Under these conditions a barite concentrate was obtained with 55 to 58% of barium and metallurgical recoveries of 91-94%.

The specific weight control to verify the quality of the products from froth flotation experiments revealed itself a fast, inexpensive and good methodology.

REFERENCES

1. Brasil. Sumário Mineral. Departamento Nacional da Produção Mineral. Coord: Lima, T.M. and Neves, C.A.R 135 p. 2016.
   Villela, M.. CBPM arrenda área de barita para pesquisa complementar. Mining.com – Notícias. Accessed: http://noticiasmineracao.mining.com/2016/12/27/cbpm-homologa-

pesquisa-de-barita-do-sincora-a-fibra-participacoes/ in 30/04/2018.
Mello, E.Z.V. de. Estudo da ocorrência de fluorita, barita e metais básicos da Fazendo Jurema, Barra da Estiva, Bahia. PhD thesis. Instituto de Geociências da Universidade de São Paulo. 221 p. 1982.
Dean, W.E Jr.. Determination of carbonate and organic matter in calcareous sediments and sedimentary rocks by loss on ignition: comparison with other methods. Journal of sedimentary petrology. 44, 1, 242-248. 1974
Luz, A.B. da and Baltar, C.A.M. Rochas e Minerais Industriais: Barita. Coord: Luz, A.B. da and Lins, F.A.F.. CETEM – Centro de Tecnologia Mineral. 990p. 2008.