

TAILINGS CHARACTERIZATION OF „CHELOPECHENE” TAILINGS POND

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Abstract

The composition of Kremikovtzi deposit is complex. The main component is iron and secondary components are barite, lead, manganese. The beneficiation in the Mineral Processing Plant by 1990 year included magnetizing roasting and is produced iron and barite concentrates. The technological tailings (called „black tailings”) are stored at “Chelopechene” Tailings Pond. The black tailings were characterized. The data from laboratory tests indicate that this tailings product is suitable to be used as raw material for flotation recovery of barite if an appropriate technology is developed.

Key words: Tailings characterization, Barite

1. Introduction

Kremikovtzi deposit is situated about 20 km to the Northeast of Sofia. The composition of the deposit is complex. The main component is iron and secondary components are barite, lead, manganese. The iron ore is represented by three main types: hematite, siderite and limonite ore. The hematite ore is about 12% of the whole ore and it is situated at the Northwest part of the deposit. It occurs in isolated large and small bodies in limonite and siderite ores. The siderite ore comprises 18% of the total ore and this makes it the second largest industrial iron reserves after the limonite. It is situated principally at the lower levels of the deposit. Limonite ore is about 70%. It is the main ore which is formed as a result from siderite oxidation at the upper parts of the deposit. The average barium sulphate (barite) content in iron ore is about 19%. Apart from that barite occurs in separate independent bodies representing interlayers in iron ore or outside it. During exploitation of the deposit selective mining of all three types iron ore was not possible, therefore raw material which was supplied to Mineral Processing Plant was composed of hematite, limonite and siderite.

The beneficiation flowsheet in the Mineral Processing Plant by 1990 year included the following operations: primary crushing to 300 mm, washing, secondary crushing to 80 mm, fine crushing to 20 mm, magnetizing roasting, grinding, classification, magnetic separation and flotation (Apostolov 1994; Georgiev 1994).

The magnetizing roasting was executed to provide magnetic properties to poor oxide iron ores, which aims their further beneficiation by magnetic separation.

The final objective of beneficiation process was to obtain iron and barite concentrates with the following quality parameters:

- Magnetic iron concentrate – iron content is 49-50%, iron recovery is 68%.
- Flotation iron concentrate – iron content is 37%, iron recovery is 85%.
- Barite concentrate - barium sulphate content is 85%.

The final technological tailings (called „black tailings”) are stored at “Chelopechene” Tailings Pond.

The main objective of this work is characterization of technological tailings (called “black tailings”), which had been obtained at the “Kremikovtzi” Mineral Processing Plant by 01.07.1990 using flowsheet including magnetizing roasting, in order to find out the possibility to use the tailings as raw material for barite (BaSO_4) flotation recovery.

2. Methods and Materials

In order to find out the main characteristics of “black tailings”, a representative sample was supplied from “Chelopechene” Tailings Pond the following characteristics of the sample, indicated “B-1” and its products were determined:

- Granulometric composition;
- Barite, barium oxide and barium sulphate content via chemical assay;
- Granulometric composition after dry grinding;
- Yield, content and recovery of iron and granulometric composition of non-magnetic fraction after rougher and cleaner dry magnetic separation;

A complex X-ray thermal analysis and mineralogical analysis have been conducted on non-magnetic fraction, which is obtained by magnetic separation using permanent magnet.

2.1. Sieve analysis of the technological “black tailings”, sample “B-1”

In order to be determining granulometric composition of “black tailings” by vibration sieve analyzer „Retsch”, the following sieves were used – 0.315 mm; 0.250 mm; 0.200 mm; 0.160 mm; 0.125 mm; 0.080 mm; 0.063 mm.

The tests were conducted by the methods of:

- Dry particle size analysis using sieves: 0.315 mm; 0.250 mm; 0.200 mm; 0.160 mm; 0.125 mm;
- Wet particle size analysis using sieves: 0.080 mm; and 0.063 mm;

2.2. Chemical assay of the technological “black tailings”, sample “B-1”

Chemical assay of the representative sample “black tailings” was conducted at the Central Research Laboratory “Geohimia” at University of Mining and Geology “St. Ivan Rilski” by ICP OES assay after decomposition by a mixture of acids.

2.3. Complex X-ray thermal analysis and the mineralogical analysis

The representative sample “black tailings” was taken and was slightly comminuted in advance and sieved by screen 0.4 mm, and then dry magnetic separation was carried out by permanent magnet.

The non-magnetic fraction which was obtained was submitted for the complex X-ray thermal analysis and mineralogical analysis.

2.3.1. Complex X-ray thermal analysis of the non-magnetic fraction

Equipment and method: X-ray analysis

Radiographic studies were carried out by Diffractometer Siemens D 500

2.3.2. Mineralogical analysis

As a result of the mineralogical analysis using polarizing microscope “POLAN” 311, mineral phases and their forms of presence were found out in non-magnetic fraction.

2.4. Dry grinding and sieve analysis of ground sample “B-2”

The dry grinding was carried out in order to achieve better mineral liberation before magnetic separation. Figure 1 presents flowsheet of the laboratory tests that have been carried out.

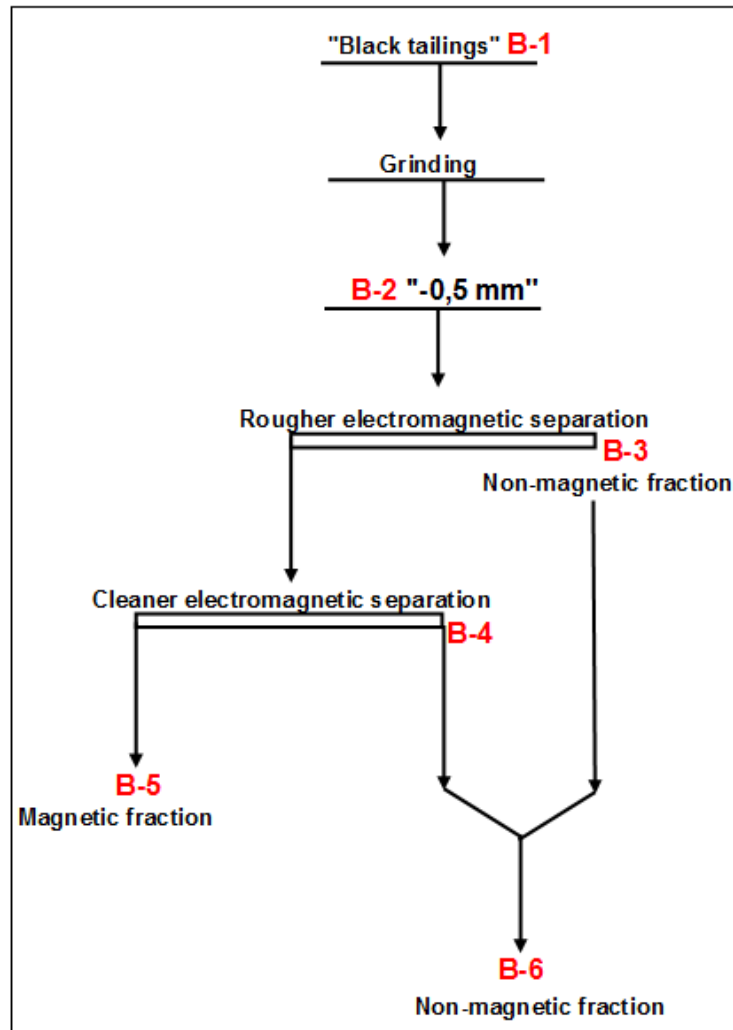


Fig 1. Flowsheet representing conducted laboratory tests

The representative sample "black tailings" (B-1) was ground in disc mill by scavenger screening through sieve 0.5 mm.

Sieve analysis was carried out to the ground sample (B-2):

- Dry particle size analysis by 0.4 mm; 0.25 mm and 0.16 mm sieves;
- Wet particle size analysis by 0.08 mm sieve.

2.5. Dry magnetic separation

The dry magnetic separation was conducted to ground sample (B-2) using laboratory induction roller magnetic separator, including rougher and cleaner operations. A weak magnetic field was generated with magnetic induction B (magnetic flux density) 0.2 T with resistance 8,5 Ω and tension 3,8 V.

3. Results and Discussions

3.1. Sieve analysis of the technological “black tailings”, sample “B-1”

The results from the sieve analysis are presented in Table 1.

Table 1. Particle size distribution of “black tailings”, sample “B-1”

Particle size, mm	Yield, %
+0.315	14.86
-0.315+0.250	7.85
-0.250+0.200	7.93
-0.200+0.160	8.26
-0.160+0.125	9.70
-0.125+0.080	12.98
-0.080+0.063	4.34
-0.063	34.08
Total	100.00

The results from the granulometric analysis of “black tailings”, sample “B-1” shows that pre-grinding is necessary to achieve better mineral liberation before magnetic separation.

3.2. Chemical assay of the technological “black tailings”, sample “B-1”

The results from the chemical assay are presented in Table 2.

Table 2. Chemical assay results of representative sample “B-1”

Chemical parameters, (%)	Contents, (%)
Al ₂ O ₃	1.78
BaO	16.02
CaO	3.68
Fe ₂ O ₃	39.80
K ₂ O	1.13
MgO	1.09
MnO	9.06
Na ₂ O	<0.05
P ₂ O ₅	0.04
SO ₃	7.59
SiO ₂	12.64
TiO ₂	0.08
LOI	6.57

Percentage contents of Ba and BaSO₄ in representative sample (B-1) are calculated by the relevant molecular weight and presented in Table 3.

Table 3. Content of Ba, BaO and BaSO₄ in representative sample (B-1)

Sample	BaO, %	Ba, %	BaSO ₄ , %
"B-1"	16.02	14.35	24.39

Chemical assay results show that BaSO₄ content in “black tailings” is about 25%. Good quality barite concentrate will be anticipated, in case an appropriate technology is implemented.

3.3. Complex X-ray thermal analysis and the mineralogical analysis

3.3.1. Complex X-ray thermal analysis of the non-magnetic fraction

The researched sample of the non-magnetic fraction consists mainly of barite - 39%, iron oxides and hydroxides (hematite - 16%, magnetic hematite (γ -hematite) - 13% and goethite - 3%). Other minerals but in subordinate quantity compared with them are also presents quartz - 11%, calcium - 9% romanechite - 8%.

The presence of relatively high content of maghemite (γ -hematite) 13% was found out in laboratory test, it shows strong magnetic properties that give us reason to apply magnetic separation with weak magnetic field for beneficiation of highly magnetic ores. The X-ray analysis of non-magnetic fraction is shown in Figure 2.

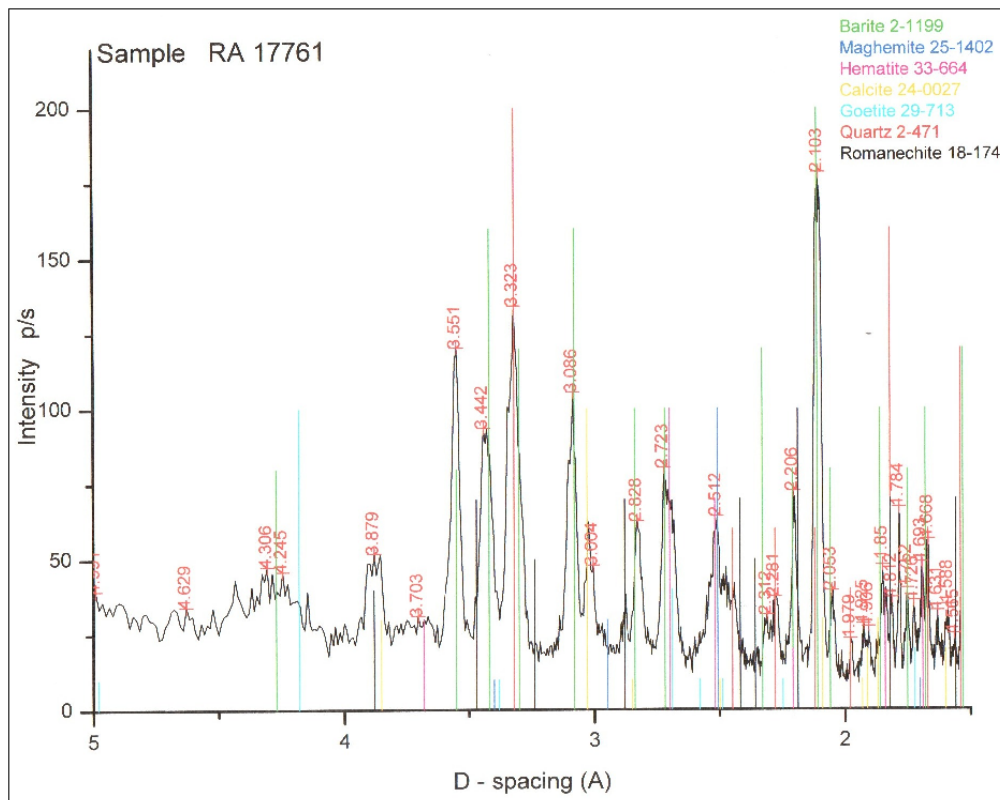


Fig 2. The X-ray analysis of non-magnetic fraction

3.3.2. Microscopic description of the mineral phases in the non-magnetic fraction

Barite BaSO₄

Barite is the mineral phase that prevails in quantity. It is mainly observed in the form of loose particles and in rare cases in the form of inclusions in Fe oxides and hydroxides. It forms separate elongated particles in fragments with irregular, angular morphology, whose size reaches 400-500 μ m. Individual larger elongate particles more than 600-700 μ m in size were observed.

Hematite Fe_2O_3

It is observed in the form of dense particles or fragments with microporous texture gray-white to white in color, azeotropic with red internal reflections. Holomorphic aggregates of dehydrated Goethite-hematite aggregates were found out. There are also single particles of fiber hematite 300-400 μm in size.

Magnetic hematite (γ -hematite) γ - Fe_2O_3

In reflected light it is gray-white with yellowish hue, isotropic with brownish red internal reflections. Dense homogeneous particles and fragments having microporous texture and numerous inclusions of quartz xenomorphic ranging from 20-30 to 100 μm in size are observed. It is more unusual to find larger quartz aggregates larger in size or barite inclusions in maghemite.

Goethite α - $FeOOH$

It is gray with rusty brown internal reflections in reflected light. Compared with hematite and maghemite its quantity is insignificant. It is represented by coliform or micro porous particles, often with numerous fine quartz inclusions. The particle size is most often up to about 500 μm .

Quartz SiO_2

The mineral is represented as independent particles or as inclusions in Fe oxides and hydroxides. Separate quartz individuals are observed with size around and more than 600 μm with irregular angular contours pigmented by dust inclusions and micron hematite inclusions.

Quartzite $CaCo_3$

The quartzite can be observed in the form of individual particles most often angular in shape homogeneous fragments to 500-600 μm in size. In reflected light it is light gray with colorless internal reflection with polysintetic intergrowths.

Romanechite $(Ba,O,OH)_2Mn_5O_{10}$

The mineral forms elongated, rectangular or angular fragments in most cases with size 50-100 to 200-300 μm , but there are also particles with larger sizes 400-500 μm . In some, romanechite fragments are observed inclusions of goethite dendrites aggregates.

3.4. Dry grinding and granulometric analysis of ground sample "B-2"

The results from the sieve granulometric analysis of the representative ground sample "B-2" are presented in Table 4.

Table 4. Particle size distribution of representative ground sample "B-2"

Particle size, mm	Yield, %
+0.40	1.61
-0.40 + 0.25	11.38
-0.25 + 0.16	6.06
-0.16 + 0.08	38.70
-0.08	42.25
Total	100.00

The results from the sieve analysis of the representative ground sample "black tailings" show that almost all of the material is under 0.4 mm as the larger amount is under 0.16 mm – about 80%. According to the data from the mineralogical analysis individual minerals have well mineral liberation and the material is prepared for magnetic separation.

3.5. Dry magnetic separation

The results from the product yield, content and recovery of iron in the output products obtained after rougher and cleaner magnetic separation of sample "B-2" are presented in Table 5.

Table 5. Yield, content and recovery of iron in the output products of rougher and cleaner magnetic separation of sample "B-2"

Product	Yield, %	Content Fe, %	Recovery ε_{Fe} , %
B-3	58.44	23.98	52.15
B-4	22.06	26.81	22.02
B-6	80.50	24,75	74.17
B-5	19.50	35.59	25.83
B-2	100.00	26.87	100.00

A certified chemical assay laboratory was assigned to carry out a chemical assay of the material feeding barite flotation after high intensity magnetic separation of the "raw tailings" that was obtained in "Kremikovtzi" Mineral Processing Plant after 1990 in order to be compared with "black tailings".

Iron content in "raw tailings" is 24.02 %, while iron content in products which have undergone magnetic separation with weak magnetic field in laboratory researches (non-magnetic fraction) of "black tailings" is 24.75%.

The results from the chemical assay show that the iron content in the product obtained in laboratory conditions (non-magnetic fraction) is close to the iron content in the "raw tailings", obtained after 1990 that used to feed "Kremikovtzi" Mineral Processing Plant.

Sieve analysis was carried out to the products from magnetic separation. The analysis results are presented in Table 6.

Table 6. Particle size distribution of obtained products from magnetic separation

Product	Particle size, mm	Yield, (%)
B-3.1	+0,4	3.05
B-3.2	-0.4 + 0.25	13.11
B-3.3	-0.25 + 0.16	7.10
B-3.4	-0.16 + 0.08	37.50
B-3.5	-0.08	39.24
B-3	Total	100.00
B-4.1	+0.4	1.79
B-4.2	-0.4 + 0.25	10.15
B-4.3	-0.25 + 0.16	9.27
B-4.4	-0.16 + 0.08	31.68
B-4.5	-0.08	47.11
B-4	Total	100.00

B-5.1	+0.4	1,44
B-5.2	-0.4 + 0.25	11,05
B-5.3	-0.25 + 0.16	9,05
B-5.4	-0.16 + 0.08	21,61
B-5.5	-0.08	56,85
B-5	Total	100,00
B-6.1	+0.4	2.71
B-6.2	-0.4 + 0.25	12.30
B-6.3	-0.25 + 0.16	7.70
B-6.4	-0.16 + 0.08	35.91
B-6.5	-0.08	41.38
B-6	Total	100.00

The results in Table 6 show that prevailing particle size in magnetic fraction is (- 0.08 mm) – 56.85%. The particles in non-magnetic fraction are presented by coarse granules.

4. Conclusions

Iron content in obtained product (non-magnetic fraction) after magnetic separation on “black tailings” with weak magnetic field is 24.75%, which approximately equals iron content (24.02%) after high intensity magnetic separation of the “raw tailings” obtained in “Kremikovtzi” Mineral Processing Plant by new technology used after 1990 year and was fed as raw material for flotation recovery of barite (BaSO_4).

Laboratory experiments including dry grinding, magnetic separation with weak magnetic field and obtained results from granulometric analysis, chemical assay, complex X-ray thermal analysis and the mineralogical analysis show that the “black tailings” obtained in “Kremikovtzi” Mineral Processing Plant before 1990 year using technology including magnetizing roasting has qualities approximately equal to the qualities of the “raw tailings” obtained after 1990 year. This statement shows that tailings product is suitable to be used as raw material for flotation recovery of barite (BaSO_4) if an appropriate technology is developed.

5. References

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