

Mineralogical Analysis of an Out-of-Balance Ore Sample of the Kalmokir Mine

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ABSTRACT

Today, the development strategy of the 21st century on a global scale is called the "essence of sustainable development", referring to the fact that the development of the economy - in a state that does not violate the stable balance of the biosphere, does not violate the natural climate and the developing environment. In this place, man-made waste is considered as a problem that prevents the sustainable development of the world economy, and the most dynamically developing industry of non-ferrous metallurgy, as the leading enterprises producing man-made waste, is the leading copper, gold and silver manufacturing industry. It is important to create and apply technologies for the extraction of non-ferrous and rare metals by recycling man-made waste.

Diffractometric and quantitative mineralogical analyzes were performed to determine the mineral content of the out-of-balance ore sample of the "Kalmokgyr" mine. Diffractometric analysis allows to determine the ore content of the main minerals with a share of 1% in the sample. The amount of feldspars expressed in potassium feldspars is 12.05% in total. The sample contains chlorite; its share is 16.3%. Mica represented by sericite and muscovite is 13.58%. The out-of-balance ore is characterized by the presence of a clay fraction represented by hydromica and kaolinite, which is 4.3% in the sample. The total amount of carbonates represented by calcite and dolomite is 3.6%. 3.3% of gypsum and 3.2% of amphiboles and pyroxenes were found in the balanced ore.

The degree of mineralization shows the amount of useful mineral in free form (100% dissolved particles) and the percentage of the mineral content. Minerals are divided into categories according to the degree of opening. Table 1.1 defines the categories. The location patterns of ore minerals (chalcopyrite and molybdenite) in the out-of-balance ore sample were studied by analyzing the ore at R80 200, R80 100 and R80 74 μm size, and the purpose of this study was to obtain comparative descriptions of the main minerals at different ore sizes. .

Table 1.1 Opening categories of minerals

Opening categories of particles	The percentage of exposed mineral surface of the particle
Fully Unlocked (Free)	100
It's open	$90 < X \leq 100$
Valuable, partially opened	$60 < X \leq 90$
Average quality, partially opened	$30 < X \leq 60$
Low value, partially opened	$10 < X \leq 30$
Very little value, almost closed	$0 < X \leq 10$
Closed	0

Table 1.2 shows the granularity of out-of-balance ore at different crushing sizes. Figure 1.1 shows the granularity of samples of different sizes.

The resulting mineral size data in Figure 1.1 confirm the size recorded for electron microscopy.

Table 1.3 shows the results of measuring the chemical composition of chalcopyrite and molybdenite. Chalcopyrite, the main sulphide of copper, is characterized by a composition close to the standard with a slight variation in the ratio of copper, iron and sulfur. Molybdenite has a wide range of molybdenum content, ranging from 54.9 to 67.6%, as opposed to the standard 62%. In addition to chalcopyrite, other copper minerals are present in an off-balance ore sample.

Table 1.2 Characterization of granularity of out-of-balance ore at different crushing sizes

Size class, mm	Sample size					
	R ₈₀ 200 μm		R ₈₀ 100 μm		R ₈₀ 74 μm	
	Class output, %	Total output, %	Class output, %	Total output, %	Class output, %	Total output, %
250-500	23,93	100,0	1,10	100,0	0	
150-250	16,1	78,09	10,72	98,88	4,57	100,0
100-150	7,93	63,78	15,66	88,27	7,45	91,14
71-100	5,04	54,10	11,24	72,48	9,83	87,60
45-71	8,81	49,33	13,46	61,86	15,98	78,55
38-45	3,76	40,90	4,45	48,36	5,88	62,74
20-38	8,34	38,15	12,28	43,71	15,59	55,89
10-20	13,02	28,83	15,48	31,85	20,83	41,95
5-10	11,43	14,10	11,13	15,98	13,88	23,62
0-5	1,64	1,85	4,48	4,93	5,99	6,74
Total	100,00	-	100,00	-	100,0	-

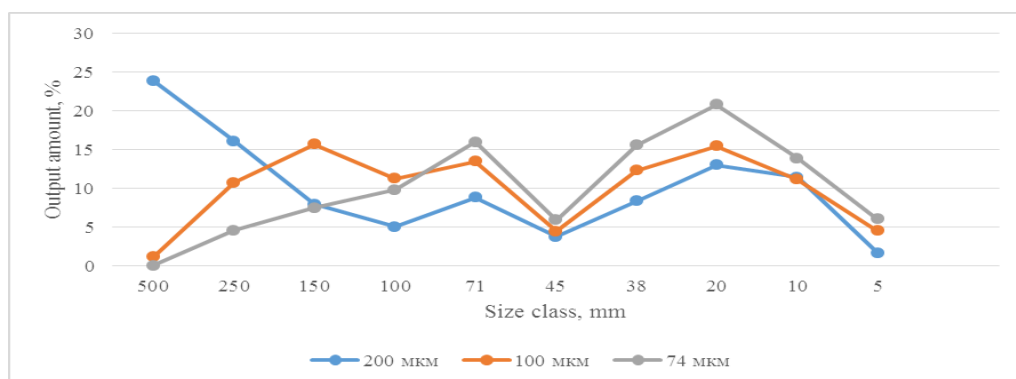




Figure 1.1. Granularity description of an out-of-balance ore sample

During the detection period, the main copper mineral chalcopyrite is counted in the off-balance ore sample. Its share is 51.6% of the total mass of copper. Secondary copper sulfides and tarnished ore contain a total of 15.3% copper. The remaining copper is divided into copper oxides of various compositions. Among them, copper carbonates and bound copper dominate, including chrysocolla content.

Table 1.3 Chemical composition of chalcopyrite and molybdenite in the out-of-balance ore sample

Naming of the mineral	Mass fraction, %			
	Cu	Fe	Mo	S
 Chalcopyrite	34.23	33.16	-	32.68
	33.24	34.50	-	33.28
	34.35	33.60	34.56	34.18
	36.68	31.89	-	31.48
	34.39	32.85	-	32.19
	31.17	36.28	33.65	30.63
	30.75	32.86	-	33.58
	36.04	30.48	31.28	32.57
	30.10	32.58	-	36.56
	33.65	33.20	-	34.22
 Molybdenite	-	-	59.69	42.33
	-	-	67.48	35.60
	-	-	58.23	42.88
	-	-	54.90	45.18
	-	-	63.48	35.68

The results of the chalcopyrite and molybdenite assays in the off-balance ore sample are described in separate sections below. Due to the presence of a high percentage of copper in the composition of secondary copper sulfides, properties of copper sulfides grouped together with chalcopyrite were further investigated. Due to the high percentage of copper oxides in the out-of-balance ore sample, the mineralogical-technological characteristics of the oxidized copper ore complexes were also studied for them. Chalcopyrite, molybdenite, complex of copper sulfides and complex of copper oxides are given in separate tables in the description of these minerals.

The share of copper corresponding to chalcopyrite is only half of the total amount of copper - 52.6%. Therefore, information on chalcopyrite describes only 50% of copper. The results of grain analysis of chalcopyrite in an out-of-balance ore sample at different grinding sizes are given in Table 1.4 and Figure 1.2.

As shown in Figure 1.2, the largest size of the chalcopyrite grain reaches 110-150 μm in the size of the ore R80200 μm . The R80100 and R8074 μm samples do not contain chalcopyrite grains larger than 100 μm . The main mass of copper sulfide in different sizes of the ore is represented by grains of 10-20 μm size.

Table 1.4 Grain description of chalcopyrite

Sample size	Mineral size, μm / mass %							
	0-5	5-10	10-20	20-40	40-50	50-70	70-100	110-150
R ₈₀ 200 μm	2,83	19,80	44,64	14,38	3,27	7,62	4,66	3,72
R ₈₀ 100 μm	5,69	17,38	33,19	21,64	6,40	14,30	2,63	0,70
R ₈₀ 74 μm	6,59	20,26	38,36	21,86	5,58	6,89	0,78	0,56

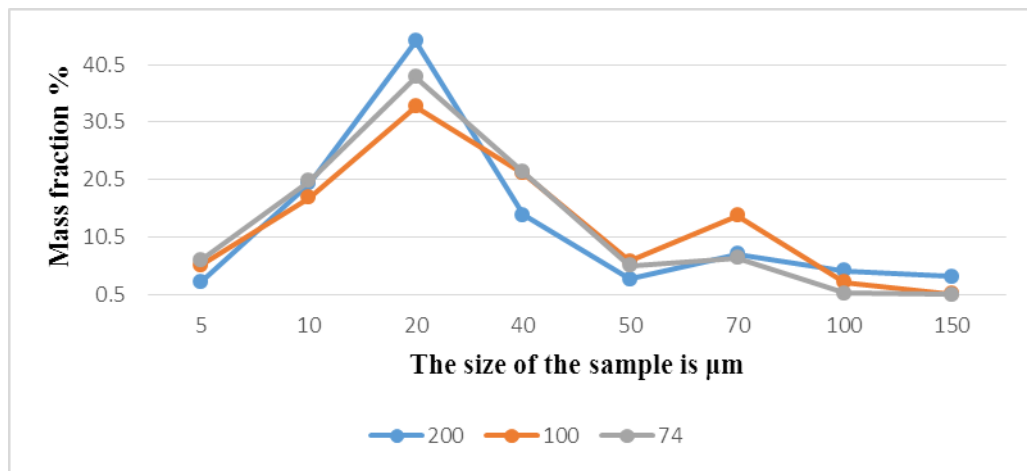


Figure 1.2. Dependence of chalcopyrite grain size on sample size

Table 1.5 and Figure 1.3 show information on the distribution of chalcopyrite by the degree of opening of particles in ore crushed to different sizes.

Table 1.5 Distribution of chalcopyrite according to the degree of particle opening

Sample size	Mineral size, μm / mass %						
	0	0-10	10-30	30-50	50-80	80-100	100
R ₈₀ 200 μm	2,85	7,42	5,88	7,21	11,21	4,78	62,30
R ₈₀ 100 μm	2.19	6.30	5.57	9,51	8,51	10,40	58,65
R ₈₀ 74 μm	1,58	2,40	3,62	5,63	10,63	6,26	70,58

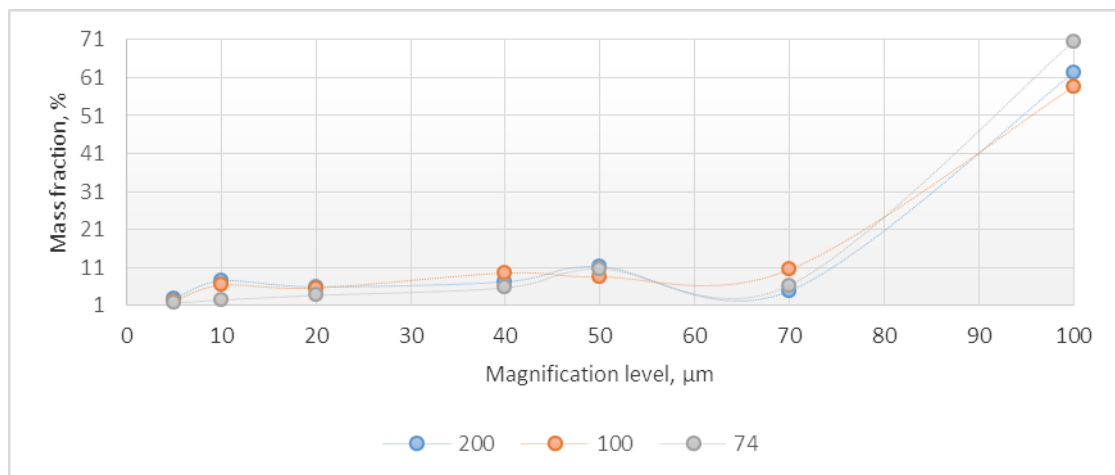


Figure 1.3. Distribution of chalcopyrite according to the degree of particle opening

As a result of our studies, the distribution of chalcopyrite according to the degree of opening in different sizes of the sample has a similar feature. However, when the size of ore decreases, closed and partially open particles of average quality are gradually redistributed into open and free particles. Thus, the percentage of free chalcopyrite particles in the sample R80200 μm size is 62.30%, and it increases to 70.58% in the R80 74 μm size.

Theoretically, the maximum possible extraction of chalcopyrite into the rough concentrate is about 78% at R80 200 and R80 100 μm size, and 87% at R80 74 μm size. In the P80 200 μm sample, the free and open fraction of chalcopyrite that can be separated by flotation is 66.10%. 33.14% of copper is extracted from chalcopyrite in the mine. When R80 grind increases to 74

µm, extraction of chalcopyrite increases by 78-56%, and extraction of copper from its total mass in the sample is 39.12%.

Potential irreversible loss of chalcopyrite in the form of thinly coated, almost closed and completely closed particles in the rock is 16-18% of the total mass of the mineral. In R80 74 µm, this indicator decreases to 6.12%.

According to the data on the mineral composition of chalcopyrite, it was found that the R80 200 and R80 100 µm minerals are similar, about 82.38-82.95% possible for the given solutions and reagents. At R80 200 µm, this indicator increases to 88.92%. A large proportion of chalcopyrite is combined with a complex of rock-forming minerals in different thicknesses of the solution, the total amount is 6-9%. 2.10-4.96% is found in pyrite derivatives of chalcopyrite. Such quality derivatives are separated by flotation in a collective sulphide concentrate. In large grinding ore samples, a real proportion of chalcopyrite is observed in combination with iron hydroxides. When crushing ore to R8074 µm, chalcopyrite is separated from derivatives with secondary minerals of iron. A small amount of chalcopyrite is combined with other minerals.

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