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Contrast Characteristics of the Muscovitic Quartzite from Karelia, Russia - Determining the Possibility of Intensification of the Beneficiation Process

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Abstract. The use of muscovite is determined by its industrial look and quality. Sheet mica is traditionally used as electrically insulating material. Crushed mica dry or wet grinding and scrap (waste from the production of sheet mica) are used as electrical insulating material (for example, mica paper), filler in the manufacture of various kinds of fillers, grout and paint etc. In addition, today there is a steady demand for micronized muscovite for the production of decorative coatings and cosmetics.
On the territory of the Republic of Karelia (Russian Federation) there is a significant number of deposits and occurrences moscoviticarum rocks. Promising target small iron-poor Muscovite is the manifestation of the Eastern Hitware identified in 1999. The average mineral composition of rocks of the productive series: quartz – 10-71%; Muscovite – 8-42%; plagioclase – 1,5-28%; kyanite – 2-13,5%; biotite, and 0.1-8%; ore (pyrite, sphalerite) and 1.5 – 11%.
Enrichment of this type of mineral raw materials may be carried out using traditional methods - gravity, magnetic separation, flotation. Textural-structural and mineralogical features, a high degree of secondary changes (thin intergrowths of muscovite with graphite, ferritization, the decrease of the strength characteristics) and the availability of areas and dedicated silicification abundant pyrite mineralization and its vein type significantly impoverish muscovite ore, necessitate the adjustment of technological schemes and modes of enrichment. Possibilities of improvement of processes of pretreatment and subsequent enrichment is possible using the methods of pre-sorting that represent rational and cost-effective alternative to traditional beneficiation processes. To explore the possibility of using the optical methods being preconcentration, experimental study of the contrast of properties of samples of the original ore. The study was carried out on crushed material, graded by size: -10+5; -20+10; -40+20 -60 and+40 mm. the results revealed the main search area colour shades in images of mineral samples in the colour system HLS – grey, brown, bright yellow-orange and purple. The correlation between the colour characteristics of the individual pieces and the content of muscovite. To implement the sort method of photometric separation, the threshold separation can be determined by one of the highlighted areas of the gamut or in their entirety. Next, the sorted ore with the same mineralogical and structural properties can effectively be enriched with gravitational methods. In the complex process of enrichment, it is possible to obtain, in addition to muscovite, quartz and kyanite products, which undoubtedly will increase the output of marketable products.

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1. Introduction

Muscovite has a wide range of uses, its use is industrial and quality. Thus, sheet mica is traditionally used as an electrical insulating material. (for example, mica paper), filler in the production of various kinds of putties, grout and paints, etc. In addition, there is still a steady demand for micronized muscovite for the production of decorative coatings and cosmetics. Enrichment of muscovite-containing mineral raw materials can be carried out using traditional methods - gravity (screw separation, concentration on tables), magnetic separation, flotation. The enriched ore is 1.6 mm in size.

2. Objects and methods

A significant number of deposits and manifestations of muscovite pegmatites [1] are located on the territory of Karelia. In the Louhi region, there were enterprises for mine extraction and processing of sheet muscovite from mica pegmatites. But by the end of the last century, because of their unprofitability, the mines were mothballed and all works are suspended. Nevertheless, a promising object of the low-iron fine-scaly muscovite is the manifestation of Eastern Khizoara (Mezhozerny). Quartz-muscovite quartzites and schists were discovered in 1999 by specialists from the Northern PRE and the Institute of Geology of the KarRC RAS [2, 3]. Muscovite-bearing rocks are represented by white and light-grey schistose quartz-muscovite metasomatites with different contents of muscovite. Throughout these rocks, silicification was observed in the form of nests, lenticles and veins 0.01-0.5 m thick, made with dark grey and white quartz. Exploratory wells establish a stable development of muscovite-bearing rocks to a depth of 70-80 m (design depth of wells). The installed thickness of the productive strata is about 200 m. The average mineral composition: quartz - 10-71%; muscovite - 8-42%; plagioclase - 1.5-28%; kyanite - 2-13.5%; biotite - 0.1-8%; pyrite, sphalerite - 1.5-11%. The development of the processes of acid leaching of the quartz-muscovite facies passed through narrow zones of schists, whereby the unevenness of the muscovitization of the rocks and, consequently, the considerable variations in the mineral and chemical composition of the rocks along the boreholes with depth are observed. Of practical interest are quartz-muscovite schists with a content of muscovite from 18 to 30%. They constitute up to 70% of the total mass of the rock.

But such factors as texture-structural and mineralogical features, thin intergrowths of muscovite with graphite, ferrugination, decrease in strength characteristics, the presence of silicification zones, pyrite mineralization of vein and interspersed type, significantly dilute muscovite ore. This causes the need to adjust the technological schemes and enrichment regimes [4, 5].

In connection with the development of optical separation technologies, which represent a unique, rational and cost-effective alternative to traditional enrichment processes, a study was made of the possibility of using them at the preconcentration stage. Experimental studies have been performed to study the contrast of the physical properties of muscovite quartzite samples. The study was carried out on crushed material on fractions of different sizes: -10 + 5; -20 + 10; -40 + 20 and -60 + 40 mm.

3. Results and discussion

At the stage of ore preparation after the crushing of the material in the jaw crusher, grains are formed, represented by splices of various minerals and differing in morphology:
- bulk grains almost square with muscovite and porphyroblasts of elongated kyanite crystals and plagioclase on the surface;
- angular grains with porphyroblasts of elongated kyanite crystals and plagioclase on the surface, with complete or partial ferrugination of the surface;
- elongated grains containing poikiloblast kyanite and plagioclase, with complete or partial ferrugination of the surface;
- flat elongated grains with characteristic schistosity, muscovite on the surface, a lot of black inclusions (probably graphite).

This pattern is maintained for all factions. At the same time, flat elongated grains of -50% prevail, bulk are 31%, angular - 19% of the total weight of the sample. However, correlations of the shape of the grains and with a certain type of rock are not observed, which excludes the effectiveness of using the classification in the preliminary stage.

Methods for the enrichment of mineral raw materials based on significant differences in colour (photometric, optical) are calculated for the separation of lump mineral raw materials with a variable composition and differing in structural characteristics and physicomechanical parameters important from the point of view of their practical effectiveness. In connection with this, a grain classification of 5-10 mm fraction based on muscovite optical properties (colour, gloss) was carried out (Table 1). The number of grains covered with iron hydroxide films is 41% of the total sample mass.

Table 1. Classification of muscovite grains of a fraction of 5-10 mm in terms of optical properties (colour, gloss).

Group	Attribute	Content, weight. %
1	The purest grains, pearly-milky-white	55.32
2	Grains of pearl-milky-white with a slight rusty hue	23.72
3	Grains with a pronounced light-brown ferruginous coating	8.90
4	Analog group 2, but the grains are greyish-pearly, with a slight rusty tinge	8.79
5	Dark grey, with pearlescent shine	3.27

In each fraction, at least 100 samples were studied using spectrophotometry and technical vision methods. Reflection spectra obtained from different regions of mineral objects of each size were examined using a R200-12-MIXED reflection and backscatter probe, a USB4000 spectrophotometer, and a quartz incandescent lamp. The images of these objects were also analyzed, taken with the help of a stand for colour analysis by the method of technical vision. The studies allowed to establish the main areas of search for colour shades on images of mineral samples in the HLS colour system (Figure 1) - grey, brown, light yellow-orange and violet - and establish a correlation between the colour parameters and the content of muscovite. In this case, grey shades were associated with quartz, brown and light yellow-orange presumably belong to muscovite, and purple - to areas of contamination.

Zone 1 (unsaturated)		Zone 2 (dark orange and yellow)	
H	0 - 360	H	0 - 60
L	0 - 98	L	0 - 40
S	0 - 13	S	14 - 98
Zone 3 (light orange and yellow)		**Zone 4 (violet shades)**	
H	0 - 60	H	280 - 360
L	41 - 98	L	0 - 98
S	14 - 98	S	14 - 98

Figure 1. Flower zones, isolated on the images of muscovite quartzites of the East Khizoara field, and their boundaries in the HLS colour system

Analysis of the spectral characteristics of mineral samples showed that in general, three main graphs of the spectral distributions of the reflection coefficient (1-3 in Figure 2) could be singled out.

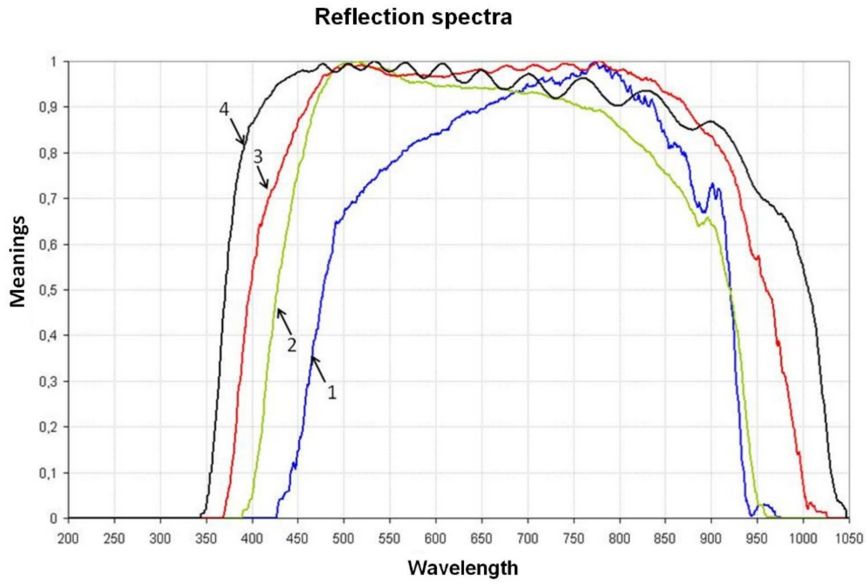

Figure 2. Basic spectral characteristics of the samples

Charts 1 and 2 have one bright peak: at a wavelength of about 780 nm for graph No. 1 and at a wavelength of about 500 nm for graph 2. Also there are graphs with two distinct reflection peaks - at wavelengths of about 520 nm and 720 Nm - as in the graph 3. In addition, on the obtained graphs of the spectral distributions of the reflection coefficient, in about half the cases an additional narrow reflection peak appears at a wavelength of approximately 900 nm (weakly expressed in graph 2 and well expressed in graph 1). In addition to the basic nature of the reflection spectrum, a certain periodic component is sometimes layered (graph 4), and it appears on different distributions.

Proceeding from the obtained reflection spectra of different regions of mineral regions, chromaticity coordinates were calculated for them (Figure 2). In accordance with the received data, it can be asserted that the bulk of the regions of objects have yellow and yellow-orange hues of different saturation and brightness (from very dark - almost black to light). There are also areas that are very close to the point of white - grey shades.

In addition, there are areas of green and blue hues in the International Lighting Commission diagram, typical for spectra with a peak of reflection at 500 nm, and for spectra with two peaks in the green and red regions. Due to the sensitivity of the colour channels of the camera, such tints on the image are displayed as purple.

Therefore, the main areas of search for colour shades on images were theoretically identified: grey (shades with a small saturation), brown (shades with a yellow-orange colour and a small value of lightness), light yellow-orange and violet.

After the corresponding correction of the chromatic effects of the used optical system and matrix on the obtained images, the object was separated from the background. The data obtained were subjected to statistical analysis. In view of the fact that the classification criterion for the separation of mineral objects under study is not known, image analysis was carried out only in the HLS colour space.

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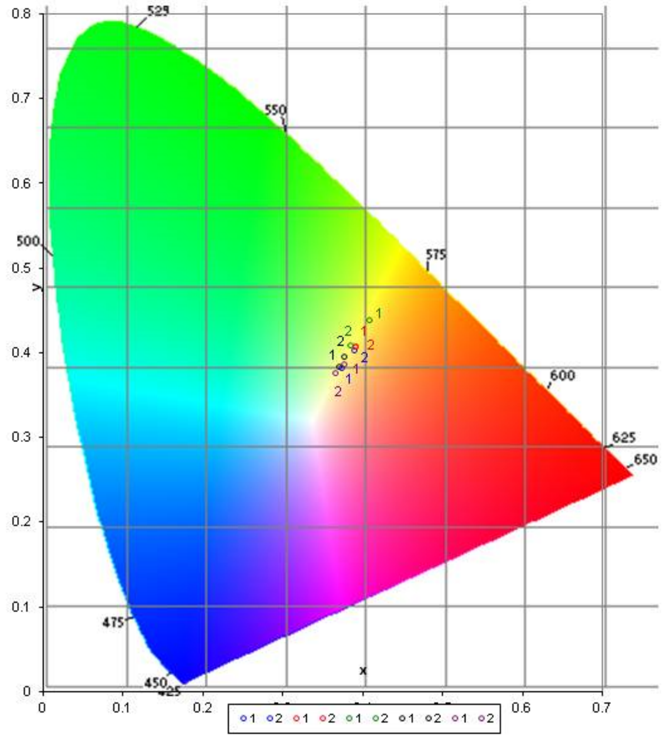

Figure 3. International Lighting Commission chromaticity scale

The content of muscovite in the studied technological sample was 26.5%. The distribution of muscovite in the size classes is uneven: 13.72% of the total quantity is 0.66 mm, which is 3.6% of the total. The content of muscovite in the slurry fraction (-0.1 mm) is 45.04% (28.96% of the total content). The highest content of muscovite is observed in the fraction -0.25 + 0.16 mm-49.7%. Muscovite detection assay (Table 2) showed that muscovite coalescences with other minerals are present in all fractions larger than 0.1 mm. Most often this is a fusion with quartz, to a lesser extent with kyanite and plagioclase. At the same time, fine muscovite is opened in small fractions, of a sixth-shaped form.

4. Conclusion

The received data completely confirm the conclusions about the colour features of objects, obtained from the results of processing the spectral distributions of the reflection coefficient. In addition, due to the presence of narrow peaks with chromaticity values of 0, 60, 120, 180, 240 and 300, it can be argued that there are pronounced patches of light on the surface of the mineral object, from which it is virtually impossible to get rid of (you can try to remove them by applying polarizing filter). However, the number of glare in the experiment, in our opinion, is not critical for the realization of a qualitative analysis of the images obtained.

Therefore, specific values of the boundaries of the selection of the above-described chromaticity zones (selective features) were determined and areas on the images of objects belonging to the given zones were calculated.

To realize the sorting of objects by the method of optical separation, the separation threshold can be determined by one of the selected chromaticity zones or by their totality. Then, the sorted ore with the same mineral-structural properties can be effectively enriched by gravity methods. The optimum fineness in this case is less than 1 mm.

Table 2. Disclosure of rock-forming minerals by fractions during ore grinding

Fraction mm	Muscovite, content %		Quartz, content %	Kyanite, content %	Plagioclase, content %	Note
	total	Including in intergrowths				
+1	28.33	100	32.55	17.25	21.87	Muscovite in uncovered intergrowths with quartz, kyanite, plagioclase
1-0.5	16.60	44.45	55.20	2.37	4.5	Clusters of muscovite with quartz - 4.69%; with kyanite - 2.64%; with plagioclase - 0,05%
05-0.4	32.59	2.82	58.30	5.60	3.60	Clusters of muscovite with quartz - 0.76%; with kyanite -0,06%; with plagioclase - 0.10%
0.4-0.315	34.60	1.45	54.70	4.90	5.60	Clusters of muscovite with quartz
0.315-0.2	44.6	0.45	49	4.40	1.9	Clusters of muscovite with quartz
0.2-0.16	44.50	0.22	47.40	5.20	2.7	Clusters of quartz with needle mica
0.16-0.1	42.50	0.12	52.70	2.50	2.0	Spicules with needle mica
0.1-0.63	19.5	0	61	13.40	2.0	Mica thin-scaly and thin-needle
0.063-0.05	25.9	0	56.00	10.8	2.8	Mica thin-scaly and thin-needle
-0.05	25.9	0	56.0	10.8	2.8	Mica thin-scaly and thin-needle

Thus, the possibilities of improving the ore preparation and subsequent enrichment processes are possible using pre-sorting methods that represent a rational and cost-effective alternative to traditional enrichment processes.

Due to the fact that muscovite manifestations of East Khizovaara is characterized by a low content of iron impurity, it is the most favourable kind of raw material for the production of pearlescent pigments. In the process of complex enrichment, in addition to muscovite concentrate, it is possible to obtain quartz, plagioclase and kyanite products. This fact has two positive aspects: the direct involvement of waste in the sphere of associated production and the receipt of additional marketable products from the same volume of mined rock, which significantly increases the economic significance of the deposit.

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