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ON THE POSSIBILITY TO OBTAIN MANGANESE CONCENTRATE FROM MANGANESE-CONTAINING TAILINGS

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The paper presents the results of studies intended to separate minerals by density in a heavy liquid. Chemical analysis found that the manganese content amounts to 16,32 % in the studied sludge sample. Manganese sludge was separated by specific gravity in M-45 heavy liquid (the aqueous solution of a complex salt of barium iodides and cadmium with a density of 3 000 kg/m^3). The tailings sample was fractioned by specific gravity in the material with a particle size of -2,5 + 1,0 mm; -1,0 + 0,5 mm and -0,5 + 0 mm. The manganese content in the heavy fraction of 3 000 kg/m^3 was 32,5 %. The manganese content in the light fraction varied from 1,7 to 2,5 %. Light fractions were represented by aggregates of quartz and calcite with manganese minerals. According to X-ray phase analysis, heavy fractions were mainly represented by minerals braunite, bixbyite, barite and hematite.

Keywords: manganese-containing tailings, extraction, heavy liquid, manganese concentrate, X-ray research

INTRODUCTION

Waste of the manganese ore beneficiation can become an alternative source for the production of manganese products due to depletion of manganese ore resources with high manganese content. Given the huge reserves of manganese-containing sludge, the development of technological solutions to extract manganese from them is an urgent scientific and industrial problem [1-5].

The beneficiation ability of manganese-containing raw materials is based on their technological properties determined by the content of manganese, silica, iron, phosphorus, the peculiarity of their distribution by mineral components; raw materials, as well as by the content of harmful impurities complicating this process and by mineralogical and petrographic composition, structural and textural features of the physical, mechanical and physical, chemical properties of minerals and mineral complexes of the ore and by the degree of contrast of these properties [6-9].

According to the beneficiation ability degree, manganese ores are divided into easily beneficiated, medium beneficiated, rebellious ores and shipping ores.

Some small beneficiation plants in the Republic of Kazakhstan engaged in ore mining and processing of manganese ores use gravity dressing. Lumpy and finely dispersed manganese concentrates are produced by sieving, with the extraction of not more than 60 – 70 wt. % MnO. The undersize screen product, the so-called "ore screening" and "sludge", are stored in grade stockpiles. These products contain a residual amount of metal that is not recovered during the beneficiation process according to the crushing-screening (washing) scheme, where the finished product is the undersize screen product.

Studies of dump samples have shown that the manganese content in them varies in the range from 5 to 19 %.

MATERIALS AND METHODS

The object of the study was manganese-containing technogenic raw materials with a particle size of less than 10 mm. The manganese content in the sludge was 16,32 %

The following analysis methods were used to identify the composition of the original raw material sources and the products produced, i.e. mineralogical, chemical, X-ray phase, X-ray fluorescence ones.

Equipment: atomic emission spectrometer Optima 2000 DV; X-ray diffractometer D8 Advance BRUKER,

Table 1 **Results of X-ray fluorescence analysis of manganese-containing sludge**

Components	Components content / %	Components	Components content / %
O	44,64	K	0,26
Mn	16,32	Ca	16,63
Fe	4,68	Ti	0,17
Na	0,28	As	0,04
Mg	0,83	Cu	0,01
Al	1,38	Zn	0,07
Si	7,04	Sr	0,13
P	0,02	Ba	6,52
S	0,07	Pb	0,002

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Cuα-radiation; X-ray fluorescence spectrometer Axios PANalytical B.V.; microscope MIN-8 (transmitted light).

The results of X-ray fluorescence analysis of the original raw material are presented in Table 1.

The original ore sludge (-5,0 +0 mm) was crushed to a size of -2,5 + 0 mm and was dispersed into classes of -2,5 + 1,0 mm; -1,0 + 0,5 mm and -0,5 + 0 mm.

The content and distribution of manganese and iron were determined in each size class. The content of manganese and iron in -2,5 + 1; -1,0 + 0,5 and -0,5 + 0 mm size classes were 17,5 %; 12 %; and 10,1 %, respectively. The fractional analysis of the identified classes of manganese-containing sludge was performed in M-45 grade heavy liquid that is a complex salt of barium and cadmium iodides (BaJ_2 CdJ_2) with a density of 2 600 kg/m^3; 2 850 kg/m^3 and 3 000 kg/m^3.

RESULTS AND DISCUSSION

The size of particles in a sludge sample was determined by sieving with a mechanical analyzer using 2,0; 1,0; 0,5; 0,315; 0,16; 0,1 mm sieves. The content and distribution of manganese and iron according to the size classes of the studied manganese-containing sludge are shown in Figures 1 and 2.

It follows from the results of granulometric analysis of manganese-containing sludges (Figures 1, 2), that the largest mass is represented by +0,5 mm size class and is 68,93 %, the other size classes vary from 3,85 % to 14,25 %.

Semi-quantitative X-ray phase analysis was performed based on diffraction patterns of powder samples using the method of equal portions and artificial mixtures. The quantitative ratios of the crystalline phases were determined (Table 2).

Interpretation of diffraction patterns was performed using the ASTM Powder diffraction file and diffraction patterns of minerals free of impurities.

X-ray phase analysis showed that the main rock-forming minerals in the ore include calcite − 41 %, quartz − 13 %, barite − 6 %; hematite − 5 %. Manganese minerals are represented by braunite $Mn_7O_8(SiO_4)$ − 10 %; bixbyite, ferrian $FeMnO_3$ – 10 and iron manganese Fe_3Mn_7 − 3 %.

Table 2 **Results of X-ray phase analysis of a sample of manganese-containing sludge**

Compound Name	Formula	S-Q / %
Iron Manganese	$Ca(CO_3)$	41
Quartz, syn	SiO_2	13
Braunite-1Q, syn	$Mn_7O_8(SiO_4)$	10
Bixbyite, ferrian	$FeMnO_3$	10
Baryte	BaSO4	6
Pigeonite	$Mg_{0,69}Fe_{0,23}$ $Ca_{0,08}SiO_3$	5
Dickite-2M1	$Al_2Si_2O_5(OH)_4$	6
Hematite, syn	$Fe_{1,957}O_3$	5
Iron Manganese	Fe_3Mn_7	3

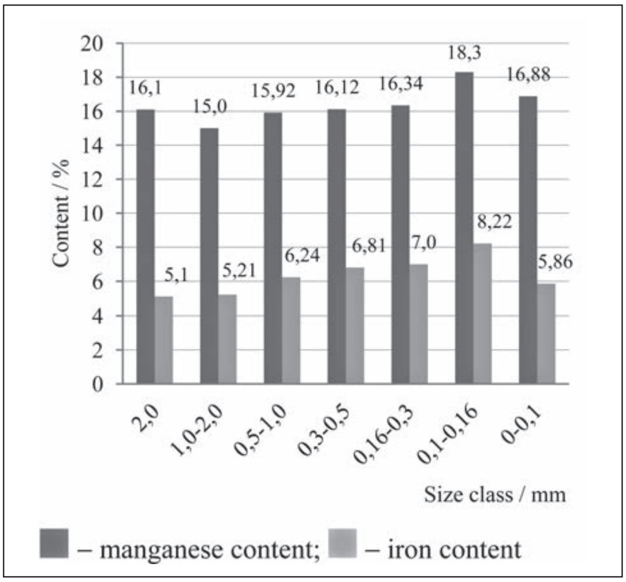

Figure 1 Manganese and iron content by size classes

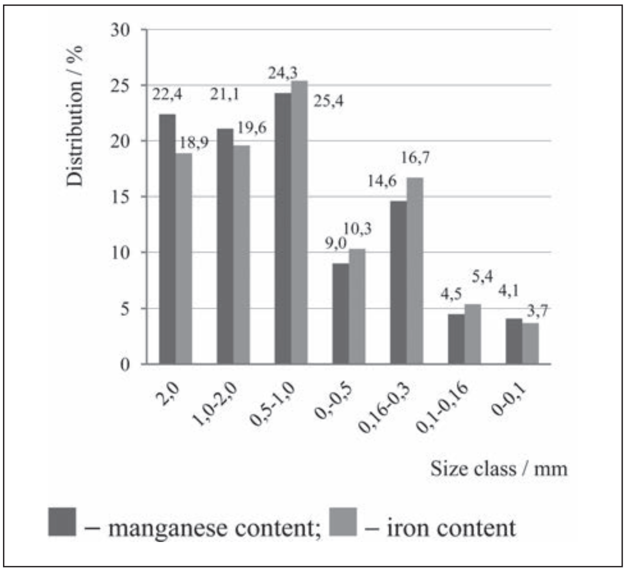

Figure 2 Distribution of manganese and iron by size classes

The examination of the polished section under a binocular magnifying glass shows that the ore is represented by grains of manganese minerals (about 20-25 %) of irregular and oval shape, brownish and black, with a metallic luster. The nonmetallic component is represented by: quartz, calcite, barite.

Braunite $Mn_7O_8(SiO_4)$ is a fine-grained, xenomorphic aggregate. The grain size of brownite reaches up to 2 mm and amounts to 10 – 15 % (of the polished sec-tion). Braunite with bixbyite are more often intergrown with each other in a nonmetallic mass and the grain size reaches 535 microns with an increase of 100; the grains are free; the degree of opening is high. Figure 3 shows braunite substituted with bixbyite in a nonmetallic mass.

The sample often contains grains of iron hydroxides up to 700 microns in length (Figure 4).

Bixbyite – sitaparite ($FeMnO_3$) is cubic crystals, light gray, with moderate reflectivity, very similar to

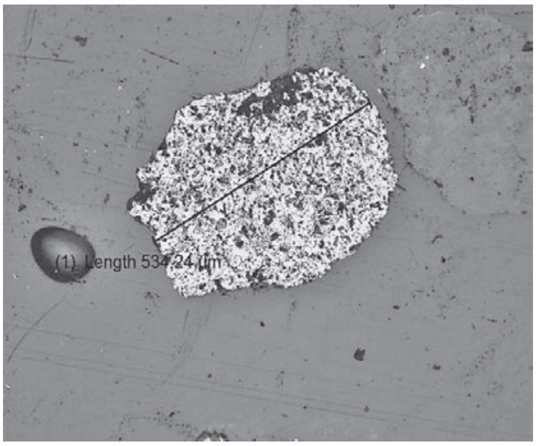

Figure 3 Braunite substituted with bixbyite in nonmetallic mass, magnification is 100

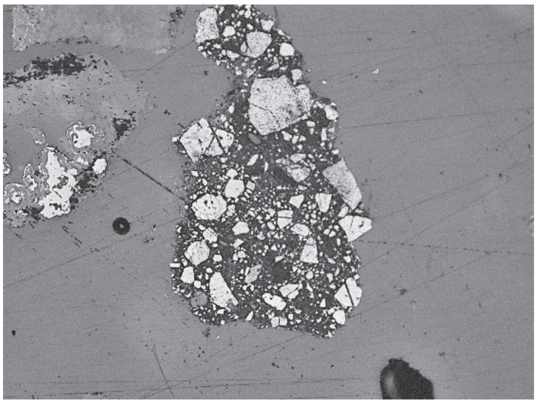

Figure 4 Iron hydroxides in intergrowth with calcite, magnification is 100

braunite (Figure 5). It is found mainly in the relict with braunite and non-metallic mass; there are free grains. Bixbyite is 10 – 15 % of the polished section area. The grain size is up to 650 microns, at a magnification of 100.

The fractional analysis is a quantitative assessment of the distribution of free mineral grains and intergrowths by dividing each class into fractions of different densities to construct curves of the minerals' beneficiation ability [9].

Fractional analysis of the selected classes -2,5 + 1,0; -1,0 + 0,5 and -0,5 + 0 mm of manganese-containing sludge was performed in the M-45 grade heavy liquid (complex salt of barium and cadmium iodides (BaJ_2, CdJ_2) with a density of 2 600 kg/m^3; 2 850 kg/m^3 and 3 000 kg/m^3.

The results of fractional analysis of the sludge sample of 0 – 2,5 mm class show that the bulk of the sample is in the range of densities of 2 650 – 2 850 kg/m^3 and is 38,3 %, the fraction with a density of less than 2 650 kg/m^3 is 16,9 %. Based upon the range of densities and microscopy, light fractions are represented by intergrowths of quartz and calcite.

The yield of the heavy fraction over 3 000 kg/m^3 was 35,9 %, which is repre-sented by free manganese minerals and intergrowths of rock-forming minerals.

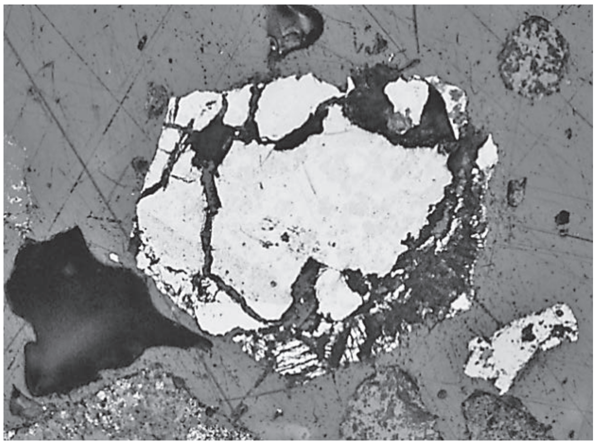

Figure 5 Grain of bixbyite in a relic with braunite and in the intergrowth of a nonmetallic mass, magnification is 200

The manganese content in heavy fractions is 30 - 32 %.

It is possible to precipitate light fractions with a density of less than 2 850 kg/m^3 from all investigated size classes. For example, when dividing the size classes -2,5 + 1,0 mm and -1,0 + 0,5 the yield of a fraction with a density of less than 2 850 kg/m^3 will be 24,65 % and 15,16 %, respectively, with a manganese content from 1,7 to 2,5 %.

CONCLUSION

The material composition of iron-manganese-containing technogenic raw materials with a content of manganese 16,32 % and iron 5,9 % has been studied.

The main valuable minerals are Braunite-1Q − 10 %, Bixbyite, ferrian − 10 %, Iron Manganese − 3 %.

Among the rock-forming minerals, calcite predominates up to 41 % and quartz up to 13 %.

Fractional analysis of the selected classes -2,5 + 1,0; -1.0 + 0,5 and -0,5 + 0 mm was performed from manganese sludge. The M-45 solution (complex salt of barium and cadmium iodides ($BaJ_2 \cdot CdJ_2$)) was used as a heavy liquid.

The results of fractional analysis of the sludge sample of -2,5 + 0 mm class show that the bulk of the sample is in the density range of 2 650 – 2 850 kg/m^3 and amounts to 38,3 %, the fraction with a density of less than 2 650 kg/m^3 amounts to 16,9 %.

Based on the range of densities and microscopy, light fractions are represented by intergrowths of quartz and calcite.

The heavy fraction contains manganese 30,0 – 32,0 % and iron more than 9,0 %. The results of the fractional analysis of manganese-containing sludge with a size class of -2,5 + 0 mm indicate the possible production of manganese concentrate by the gravity method (jigging, concentration table, and other devices), intended for the concentration of ores by specific gravity.

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REFERENCES

[1] Zhunusov A., Tolymbekova L., Abdulabekov Ye., Zholdubayeva Zh., Bykov P. Agglomeration of manganese ores and manganese containing wastes of Kazakhstan, Metalurgija 60 (2021) 1-2, 101-103.

[2] Abdykirova, G.Z., Tanekeeva, M.S., Sydykov, A.E., Diosenova, S.B. Production of electrolytic manganese dioxide from purified solutions after the leaching of manganese-bearing slurry, Steel in Translation 46 (2016) 5, 319-321.

[3] Sariev O.R., Dossekenov M.S., Kelamanov B.S., Abdirashit A.M. High-carbon ferromanganese smelting on high-base slags, Kompleksnoe Ispolʹzovanie Mineralʹnogo syrʹâ (2020) 4, 63-73.

[4] Shevko V. M., Aitkulov D. K., Badikova A. D., Tuleyev M. A. Ferroalloy production from ferrosilicon manganese dusts, Kompleksnoe Ispolʹzovanie Mineralʹnogo syrʹâ (2021) 3, 43-50.

[5] Kenzhaliyev B.K. Innovative technologies providing enhancement of nonferrous, precious, rare earth metals extraction, Kompleksnoe Ispolʹzovanie Mineralʹnogo syrʹâ (2019) 3, 64-75.

[6] Rulev N. N., Turysbekov D. K., Semushkina L. V., Narbekova S. M. Combined microflotation of fine dispersed minerals, Tsvetnye Metally (2017) 9, 14-20.

[7] Abdykirova, G., Toilanbay, G., Dyussenova, S., Kuldeyev, E. The study of beneficiation of manganese-containing raw materials, International Multidisciplinary Scientific GeoConfe-rence Surveying Geology and Mining Ecology Management, SGEM, 43 (2017) 17, 197-204.

[8] Telkov Sh. A., Raivich I. D., Bezginova L. I., Regularities of gravitational beneficiation ability of crushed ores of the main manganese deposits in Kazakhstan, Bulletin of KazNTU (1995) 1, 37-40.

[9] Gasik M. I. Manganese. Moscow: Metallurgy (1992), 607.

Note: The responsible for English language is A. Kurash, Almaty, Kazakhstan.