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Research of Chemical, Mineralogical and Fractional Composition of Silvinites of the Khodjaikan Deposit

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ABSTRACT: The chemical, fractional composition and mineralogical composition of the insoluble residue of sylvinite ore of the Khodjaikan deposit have been studied. Chemical analysis of the selected ore samples showed that they contain KCl - 24.10-29.55%, NaCl - 62.62-67.50% and u.s. - 5.25-6.44%. The main ore fraction is +0.90 mm, which decreases from 63.6% to 58.6% with an increase in the content of potassium chloride. The main amount of potassium chloride is contained in fractions +0.90 ÷ +0.165 mm. The insoluble residue of sylvinite ores contains 66.86-74.45% of non-silicate minerals and is mainly represented by carbonate and sulfate minerals. The content of silicate minerals is 25.55-33.14%. The chemical analysis data were confirmed by X-ray, IR spectroscopy and microphotography.

I. INTRODUCTION

The priority direction of the economic development of Uzbekistan is the development and involvement in industrial production of existing mineral resources, the improvement of existing and the creation of new industries based on their deep processing [1].

II. LITERATURE SURVEY

The potash industry is a new branch of the chemical industry of the Republic, based on the flotation processing of sylvinite ores from the Tyubegatan deposit into potassium chloride. Potassium is one of the most important nutrients for agricultural crops. It affects a number of physiological functions that control the processes of growth and metabolism in plants. The lack of potassium in the soil leads to various diseases [2-4]. The republic not only meets its needs in potash fertilizers, but also exports. However, with an increase in demand for potash fertilizers in the world market, there is a need to conduct research on the processing of undeveloped, new deposits of sylvinite raw materials for possible use in the production of potash fertilizers [5].

Thus, according to the UN, the production of fertilizers ($N + P_2O_5 + K_2O$) increased from 292.429 million tons in 2016 to 310.389 million tons in 2018. The production of nitrogen fertilizers increased from 180.496 million tons in 2016 to 186.974 million tons by 2018, phosphorus from 57.295 million tons to 61.951 million tons, potash from 54.638 million tons to 61.951 million. t. [6]

The Republic of Uzbekistan has the richest reserves of potassium-bearing raw materials. The salt-bearing series of the Gaurdak Formation, especially their potassium-bearing members, are most fully developed in the Gaurdak-Kuchitan region, where the deposits of potassium salts Tyubegetan, Akbash, Alimkan, Khodzhaikan, Kurmok are located [7-10]. The Khodjaikan deposit is located 84 km northwest of the city of Termez. In the thickness of rock salt with a total thickness of 123.1 m to 349 m, two packs are distinguished in color: the lower, gray with interlayers of anhydrites and the upper, pink and red, to which potassium-bearing horizons are confined. Six potassium-bearing horizons have been

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identified at the deposit, of which four (lower) are industrial. Potassium-bearing horizons are evenly distributed in the thickness of rock salt and are composed of sylvinite and carnallite of gray, pink and red colors. Industrial reserves of potassium chloride are established in the eastern part of the lower horizon, with an average content of 27.9%, salt reserves are more than 220 million tons.

The economic efficiency of exploitation of deposits depends not only on the natural conditions of occurrence of a mineral, but also on the choice of technology for its production and enrichment. The technological properties of minerals, in turn, depend on the material composition and structural and textural characteristics of the rock they make up.

III. RESEARCH METHODS

Therefore, the purpose of our research was to study the chemical and fractional compositions of sylvinite ores and the mineral and chemical composition of the insoluble residue (u.s.) of the Khodjaikan deposit [11].

IV. EXPERIMENTAL RESULTS

For research, samples of sylvinite ores with different contents of potassium chloride were selected, the mineral composition of which is shown in table 1.

Table 1. Chemical composition of sylvinites of the Khodjaikan deposit

Sample	KCl, %	NaCl, %	$CaSO_4$, %	$MgCl_2$, %	u.s., %	W, %
1	24,10	67,50	1,24	0,36	6,14	0,66
2	25,44	65,58	1,36	0,40	6,44	0,78
3	27,02	65,98	1,10	0,25	5,25	0,40
4	29,55	62,62	1,04	0,54	6,19	0,53

The content of potassium chloride varies from 24.10% to 29.55%, sodium chloride from 67.5% to 62.62%. The content of insoluble residue (u.s.) is 5.25-6.44%.
To determine the distribution of potassium chloride, depending on the size of the fractions of the incoming ore, the fractional chemical composition was studied (table 2.).

Table 2. Mineral and fractional composition of sylvinite ores of the Khodjaikan deposit

№ пп	Grain size, mm	Fraction content, %	Chemical composition, wt. %				
			NaCl	KCl	$MgCl_2$	u.s.	H_2O
The content of KCl in sylvinite is 24.10% and u.s. 6.14%							
1	+0,90	63,60	69,72	25,20	0,32	2,96	0,34
2	-0,90 ÷ +0,65	9,10	69,55	25,16	0,28	3,47	0,34
3	-0,65 ÷ +0,50	6,90	69,03	25,04	0,23	4,38	0.33
4	-0,50 ÷ +0,25	17,25	67,15	24,34	0,19	7,29	0.33
5	-0,25 ÷ +0,165	2,43	70,08	23,43	0,13	5,35	0,32
6	-0,165 ÷ +0,125	0,40	67,07	22,92	0,09	8,68	0,31
7	-0,125	0,50	65,20	22,46	0,06	10,90	0,30
The content of KCl in sylvinite is 25.44% and u.s. 6.44%							
8	+0,90	61,90	68,11	26,60	0,42	3,20	0,47
9	-0,90 ÷ +0,65	9,30	66,96	26,54	0,42	4,41	0,47
10	-0,65 ÷ +0,50	7,90	66,16	26,44	0,42	5,41	0,47
11	-0,50 ÷ +0,25	17,50	65,22	25,80	0,41	7,01	0,46
12	-0,25 ÷ +0,165	2,50	65,17	24,92	0,40	7,07	0,44
13	-0,165 ÷ +0,125	0,40	64,90	24,25	0,40	8,22	0,43

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14	-0,125	0,50	64,64	23,62	0,40	9,82	0,42
The content of KCl in sylvinite is 27.02% and u.s. 5.25%							
15	+0,90	61,90	69,78	25,02	0,42	2,49	0,49
16	-0,90 ÷ +0,65	9,30	65,46	28,21	0,39	3,59	0,55
17	-0,65 ÷ +0,50	7,90	64,86	28,08	0,32	4.40	0,54
18	-0,50 ÷ +0,25	17,50	64,21	27,46	0,29	5,70	0,54
19	-0,25 ÷ +0,165	2,50	65,08	26,47	0,19	5,73	0,53
20	-0,165 ÷ +0,125	0,40	65,17	25,76	0,12	6,65	0,50
21	-0,125	0,50	64,64	25,13	0,09	7,95	0,49
The content of KCl in sylvinite is 29.55% and u.s. 6.19%							
22	+0,90	58,60	64,38	30,91	0,37	2,81	0,43
23	-0,90 ÷ +0,65	10,70	64,05	30,86	0,37	3,24	0,43
24	-0,65 ÷ +0,50	7,90	62,97	30,71	0,37	4,42	0,43
25	-0,50 ÷ +0,25	18,10	60.44	30,03	0,36	7,65	0,42
26	-0,25 ÷ +0,165	3,40	60,12	28,91	0,35	9,12	0,40

The table shows that the main fraction of sylvinite ores is +0.90 mm. With an increase in potassium chloride in the ore from 24.10% to 29.55%, the KCl content decreases from 63.6% to 58.6%. The main amount of KCl is contained in fractions +0.90 ÷ +0.165 mm for ore with a content of 24.10 and 25.44% KCl. An increase in the content of KCl in the ore leads to a uniform distribution of KCl not to all fractions. At the same time, the content of sodium chloride in the ore decreases uniformly from 69.72% to 65.20% in the ore with a content of 24.10% KCl and from 64.38% to 60.12% in the ore with a content of 29.55% KCl.

A decrease in the size of fractions leads to an increase in n.d. for ore with a grade of 24.10% from 2.96% to 10.90%, for ore with a grade of 25.44% from 3.20% to 9.82%, for ore with a grade of 27.02% from 2.49 % to 7.95% and for ore with a grade of 29.55% from 2.81% to 9.12%. Moisture content in ores practically does not change with decreasing fractions. Table 3 shows the mineralogical composition of n.d. of previously selected four samples of ore with a difference in the content of KCl and u.s. Research have shown that u.s. sylvinite ores of the Khodjaikan deposit, according to chemical analysis, contain 66.86-74.45% of non-silicate minerals and are mainly represented by carbonate and sulfate minerals.

Table 3. Mineralogical composition of water-insoluble remains of sylvinites of the Khodjaikan deposit

Name of minerals	Mineralogical composition of insoluble impurities, wt. %				Average for ore samples
	1	2	3	4	
Sulphates	21,50	20,65	17,36	19,00	19,62
Carbonates	52,92	46,21	57,09	50,62	51,71
Total non silicate minerals	74,42	66,86	74,45	69,62	71,33
Silicates	25,58	33,14	25,55	30,38	28,66

To confirm the salt composition of u.s. X-ray diffraction patterns and IR-spectra were taken (fig. 1, 2).

The X-ray pattern has diffraction peaks related to calcium and magnesium carbonates, to two aqueous and anhydrous calcium sulfate. Peaks 5.40; 4.56; 3.16 and 2.47 Å belong to calcium sulfate, 3.40; 1.875; 1.626 Å belong to calcite, and peaks 3.38; 2.75; 2.44; 1.818; 1.434 Å - silicates.

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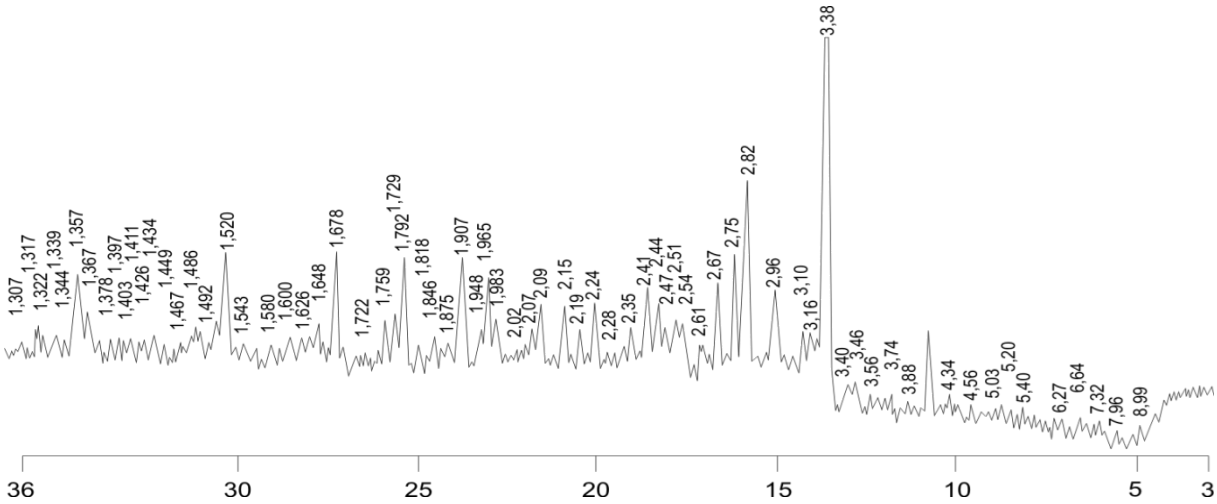

Figure. 1. X-ray pattern of the water-insoluble residue

The IR-spectra show absorption bands at 1008.44 cm^{-1} related to sulfate groups. Absorption bands 3557.42; 3430.55 cm^{-1} refer to gypsum hemihydrate and dihydrate, and absorption bands 878.32; 467.21 cm^{-1} - to silicates. These data confirm the results of chemical and X-ray phase analyses.

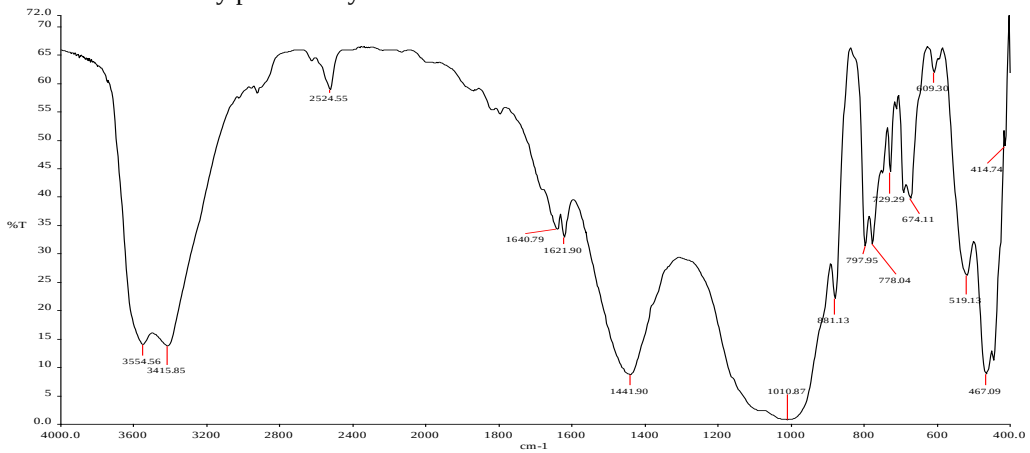

Figure. 2. IR-spectrum of the water-insoluble residue

Figure 3. shows microphotographs of the original sylvinite ore and u.s. Microscopic images were taken with an NSZ-810 stereomicroscope at 50x magnification.

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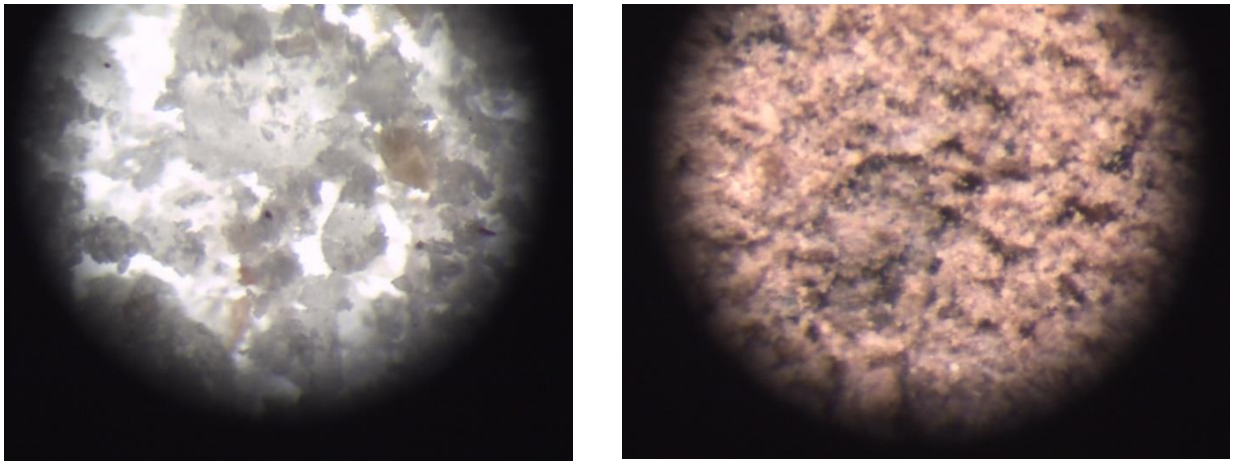

a b

Figure 3. Microscopic image of the water-insoluble residue and sylvinite of the Khodjaikan deposit: a – sylvinite, b – u.s.

Figure 3-a shows a micrograph of the original sylvinite. The bright part in the photo is sodium chloride, potassium chloride and carbonates. Dark blotches are u.s.
Figure 3-b shows a micrograph of u.s. It has more dark spots, which are due to the sulfate and silicate components of the u.s. This is another confirmation of the composition of the u.s. sylvinite ore of the Khodjaikan deposit.

V. CONCLUSIONS

Thus, the conducted studies made it possible to establish the chemical and fractional composition of sylvinite ores and u.s. sylvinites of the Khodzhaikan deposit. U.s. sylvinite ores of the Khodzhaikan deposit contain 66.86-74.45% of non-silicate minerals and are mainly represented by carbonate and sulfate minerals, which indicates the similarity in chemical and mineralogical composition of the sylvinites of the Khodjaikan deposit to the sylvinites of the Tyubegetan deposit. However, the content of u.s. in sylvinites of the Khodzhaikan deposit, it is 2.5 times higher than in sylvinites of the Tyubegatan deposit.

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