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Study of Chemical and Mineralogical Composition of Sylvinites of Tubegatan Mine

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Abstract: The study delves into the chemical and mineralogical composition of sylvinites extracted from the Tubegatan mine. Through x-ray analysis of various components, including sylvinite samples and insoluble residues obtained during experimental melting processes, the research investigates the intricate composition of these materials. By scrutinizing the results of the x-ray analysis, the study unveils crucial insights into the chemical makeup and mineralogical properties of the sylvinites. Furthermore, the research scrutinizes the process of melting different samples of sylvinite to elucidate potential variations in composition and behavior under thermal conditions. This comprehensive analysis provides valuable knowledge essential for understanding the characteristics and properties of sylvinites from the Tubegatan mine, contributing to advancements in the field of mineralogy and facilitating informed decision-making in mining and processing operations.

Keywords: sylvinite, x-ray, gallurgy, flotation, concentration, Tubegatan, anhydride

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1. Introduction

To increase the quality of potassium fertilizers, an effective way is to remove the 0.2 mm class from the flotation feed and treat it appropriately. This technique seeks to improve the efficiency of processing low-grade potash ores [1,2]. Potassium, which is required for plant growth, is frequently lacking in soils, necessitating the use of potassium fertilizer to increase crop yields and minimize insect pest damage [3]. The global supply of potassium fertilizer is large, with over 80% of potash fertilizer generated from potassium ore using technologies such as flotation [4].

In the context of potash ore processing, the standard manufacturing procedure for potassium chloride includes processes such as cold decomposition-positive flotation and reverse flotation-cold crystallization [5]. However, problems remain, such as diminishing liquid potash mineral yield in specific places, such as Qarhan Salt Lake, which limits long-term potassium fertilizer production [6]. To overcome such challenges, adjusting control parameters in processes such as gravity shaking tables can result in ongoing efficiency gains [7].

Furthermore, the beneficiation of phosphate ores has shown that methods such as reverse anionic flotation may produce high separation efficiency, emphasizing the need of selecting appropriate beneficiation techniques for diverse ore types [8]. Furthermore, mineralogical analysis of rare earth carbonate wall rock has demonstrated good resource recovery using various beneficiation processes such as magnetic separation, flotation, and leaching enrichment [9].

The galurgic method offers a potential method to obtaining high-concentration potassium chloride (KCl) at 99% while also creating pure sodium chloride (NaCl) [10,11]. This approach allows for the effective extraction of potassium chloride, which is useful for a variety of applications such as food salt manufacture and the extraction of sodium-containing compounds [10,12]. The excellent extraction efficiency of potassium chloride employing the galurgic approach demonstrates its usefulness in obtaining high-purity potassium chloride [10,13].

The galurgic method's ability to preferentially recognize and extract potassium chloride over other salts, such as rubidium chloride, demonstrates its efficacy in isolating potassium chloride [10,14]. This selectivity is critical for assuring the excellent purity of the potassium chloride produced by this method [10,15]. Furthermore, thermodynamic studies on partitioning in aqueous systems containing potassium salts indicate that certain extraction procedures can reach extraction efficiencies of up to 99% [16,17,18].

Furthermore, boosting potash ore flotation with industrial oils has been shown to enhance potassium chloride extraction levels, with efficiency ranging from 93.25% to 94.86%, which is consistent with the high extraction rates achieved using the galurgic technique [19,20,21]. This emphasizes the need of novel techniques, such as the galurgic method, in improving potassium chloride extraction from ores [19,22].

2. Method

This research was conducted by using methodology as follows.

1) **Sample Collection:** Representative samples of sylvinites were collected from various tubegatan locations within the mines to ensure a comprehensive representation of chemical and mineralogical variability. Efforts were made to obtain a diverse range of samples capturing the spectrum of compositions present.
2) **Sample Preparation:** Collected samples underwent meticulous cleaning and crushing procedures to achieve uniform particle-size sylvinites. Special attention was given to ensuring the absence of contaminants or impurities that could compromise subsequent analyses.
3) **Chemical Analysis:** Quantitative chemical analysis was conducted using advanced techniques, including X-ray fluorescence (XRF) or inductively coupled plasma mass spectrometry (ICP-MS). These methodologies facilitated the determination of major and trace element concentrations within the sylvinites.
4) **Mineralogical Analysis:** Mineralogical characterization of the samples was performed utilizing X-ray diffraction (XRD) techniques. This analytical approach enabled the identification of mineral phases present in the sylvinites, thus providing insights into crystal structure and mineralogical composition.
5) **Petrographic Analysis:** Microscopic examination of the samples was undertaken through petrographic analysis using microscopy. This method allowed for the examination of relationships within the sylvinites and provided valuable information regarding mineral texture and geological processes.
6) **Microscopic Examination:** Surface morphology of the sylvinites was examined at a micro-scale using scanning electron microscopy (SEM). This technique facilitated the observation of crystal morphology, grain boundaries, and potential secondary mineral formations, offering further insights into sample characteristics.
7) **Isotope Analysis:** Stable isotope analysis was employed to investigate the origin and geological processes associated with the sylvinites. Analysis of isotope ratios provided valuable information regarding the conditions of mineral deposition and the geological history of the samples.

3. Results and Discussion

In our research, low-grade Tubegatan sylvinites were studied. All this determines the use of the galurgic method of enrichment. In this regard, we have studied the process of melting different samples of sylvinite, determining the optimal conditions for processing low-grade sylvinite from the Tubegatan mine by galurgy method, and recommending the technological scheme of production based on these studies.

During the experiments, we used low-grade sylvinites from the Tübegatan mine. To study the composition of the raw material - sylvinite, the insoluble residues obtained during the experiments, the components were subjected to X-ray analysis.

The results of the X-ray analysis are shown in Figures 1, 2, 3 and Tables 1 & 2.

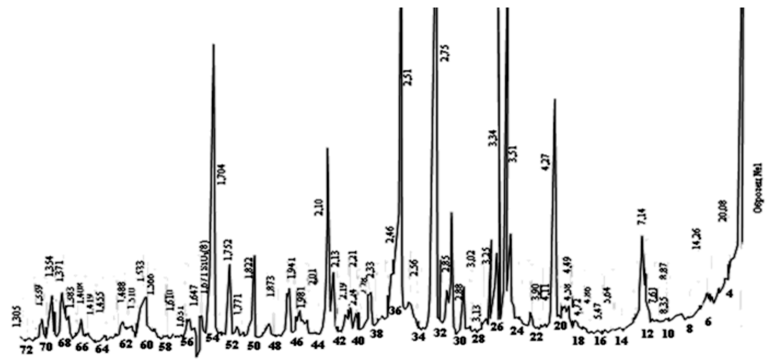

Figure 1. X-ray image of the insoluble residue of Tubegatan mine anhydride

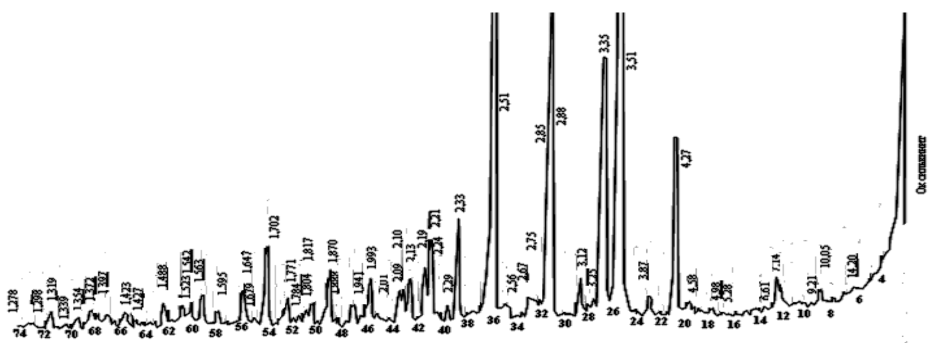

Figure 2. X-ray image of the insoluble residue of of white sylvinite from the Tubegatan mine

Table 3. Radiogram of insoluble sample residues

Red silvinit		White tuberculosisьVi		Angidirid	
d. Å	I/I0. %	d. Å	I/I0. %	d. Å	I/I0. %
18.41	24	14.26	20.8	20.8	26.8
14.26	21.6	10	18.8	14.26	22.4
11.95	17.2	9.21	17.2	10.05	19.2
10.05	24	7.14	17	dc 8.35	16.8
7.50	16	6.61	15.6	7.63	21.2
7.14	20	5.28	14.4	7.14	22.4
6.34	15.2	4.98	16	5.64	13.2
of 5.83	15	4.27	40	4.49	17.6
4.98	19.6	3.87	18.8	4.27	52
4.48	19.2	3.51	100	3.90	17.2

4.27	64.8	3.35	54	3.51	97
at 3.71	20	3.12	16	3.34	96
3.51	32	2.88	62	3.04	15.2
3.35	96	2.75	60	2.88	27.2
3.04	16.8	2.67	16	2.75	100
2.88	88	2.51	96	2.56	20
2.75	98	2.33	22	2.51	98
2.50	100	2.01	15.2	2.21	17.2
2.39	20	1.99	16	2.13	14.4
2.13	18.4	1.87	16.8	2.10	40
2.10	34	1.81	13.6	2.01	16
1.98	17.6	1.74	36	1.94	18
1.81	14.8	1.70	26	1.87	14
1.69	40	1.59	16	1.75	16
1.29	13.6	1.29	14	1.30	12.4

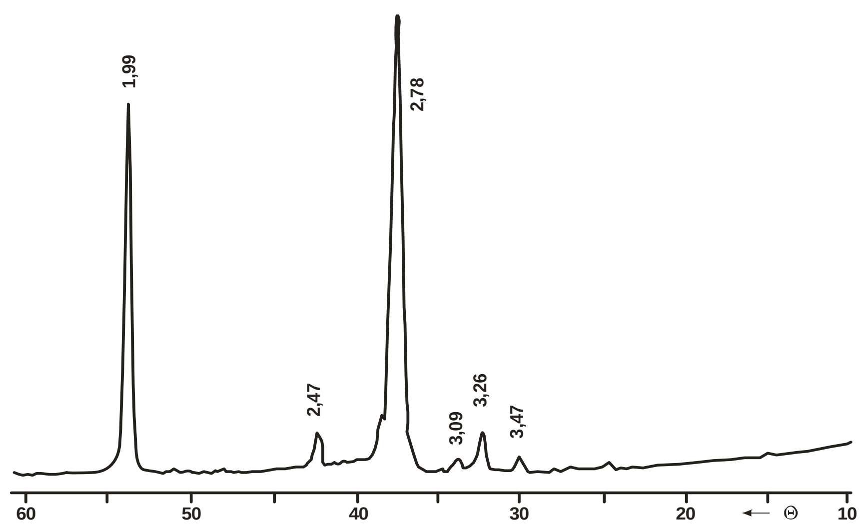

Figure 4. X-ray image of sylvinite from the Tubegatan deposit

The ash of the insoluble residue of red sylvinite contains the following macro- and microelements (%): potassium - 1; calcium - 3; magnesium - 12; aluminum - 5; sodium - 0.6; silicon - 20; ... iron - 4; manganese - 0.06; barium - 0.02; titanium - 0.4; molybdenum - 0.0005; nickel - 0.02; silver - 0.0001 zinc-0.01, lithium-0.004, gallium-0.001, cobalt-0.002, copper-0.002, vanadium-0.007, zirconium-0.1.

Table 2. X-ray analysis results of the insoluble residue of sylvinite samples from the Tubegatan mine

N	Naming of components	Red silvinit, %				White silvinit,%				Co2%			
		characteristic				characteristic				Characteristic			
		1	2	3	4	1	2	3	4	1	2	3	4
1	$CaSO_4$	32	17	15.6	13.7	100	36	34	22	97	33	18.8	16
2	SiO_2	96	64	26	19.6	54	38	19	15	96	52	19.3	18
3	$Al_2O_3SiO_2$	40	38	19	38	17	48	22	19	63	19	24	16
4	Ca_2SiO_4	98	66	74	33	60	36	48	54	100	35	13	53
5	$MgFe_2O_4$	100	86	39	23	96	29	34	49	98	40	19	26

The ash of the insoluble residue of red sylvinite contains the following macro- and microelements (%): potassium - 1; calcium - 3; magnesium - 12; aluminum - 5; sodium - 0.6; silicon - 20; ... iron - 4; manganese - 0.06; barium - 0.02; titanium - 0.4; molybdenum - 0.0005; nickel - 0.02; silver - 0.0001 zinc-0.01, lithium-0.004, gallium-0.001, cobalt-0.002, copper-0.002, vanadium-0.007, zirconium-0.1.

The ash of the insoluble residue of white sylvinite contains the following macro- and microelements (%): potassium - 0.8; calcium - 20; magnesium - 12; aluminum - 3; sodium - 0.6; silicon - 12; ... iron - 3; manganese - 0.1; barium - 0.02; titanium - 0.2; molybdenum - 0.0005; nickel - 0.04; silver - 0.1 zinc-0.03, lithium-0.002, gallium-0.001, cobalt-0.001, copper-0.02, vanadium-0.004, zirconium-0.008.

The ash of the insoluble residue of anhydrite contains the following macro and microelements (%): potassium - 1; calcium - 5; magnesium - 20; aluminum - 5; sodium - 0.6; silicon - 25; iron - 3; manganese - 0.08; barium - 0.02; titanium - 0.5; molybdenum - 0.0004; nickel - 0.02; lithium-0.01, gallium-0.001, cobalt-0.002, copper-0.001, vanadium-0.006, zirconium-0.008

The ash of red sylvinite contains the following macro and microelements (%): potassium - 6; calcium - 1; magnesium - 1; aluminum - 0.08; sodium - 30; silicon - 1; iron - 0.08; manganese - 0.06; barium - 0.02; titanium - 0.4; molybdenum - 0.0005; nickel - 0.02; silver - 0.0001 zinc-0.01, lithium-0.004, gallium-0.001, cobalt-0.002, copper-0.002, vanadium-0.007, zirconium-0.01.

Ash of white sylvinite contains the following macro- and microelements (%): potassium - 1; calcium - 5; magnesium - 1; aluminum - 0.1; sodium - 25; silicon - 0.8; ... iron - 0.02; manganese - 0.1; barium - 0.02; titanium - 0.2; molybdenum - 0.0005; nickel - 0.04; silver - 0.1 zinc-0.03, lithium-0.002, gallium-0.001, cobalt-0.001, copper-0.02, vanadium-0.004, zirconium-0.008

Thus, the analysis of the results shows that the insoluble compounds mainly consist of $CaSO_4$ and SiO_2. To fully study the composition and insoluble residues of sylvinite samples, they were subjected to elemental analysis.

4. Conclusion

The study has provided valuable insights into the chemical and mineralogical composition of the geological and depositional history of the mine's tubegatan sylvinites from the deposit. The combination of analytical techniques including xrf, XR, SEM, and isotope analysis has allowed for a comprehensive understanding of the sylvinite samples.

The chemical analysis revealed the concentrations of major and trace elements, shedding light on the potential economic significance of the deposit. Mineralogical analyses, and petrographic examination through the xr, the identified mineral phases present your interpretation of the depositional environment and geological processes involved in the aid.

Provided detailed insights into the microscopic examination using SEM surface morphology, crystal structure, potential, and diagenetic features. Isotope analysis further contributed to the understanding of the origin and evolution sylvinites, enhancing the overall geological interpretation.

This server as a foundation for future research efforts in the study of tubegatan mines and exploration, resource evaluation and extraction, providing essential information for planning. Additionally, the methodology employed in this study can be an adapter for the other wires in the investigation of geological settings.

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