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RESULTS OF SCANNING ELECTRON MICROSCOPY STUDIES OF BRUCITE, MAGNESIUM HYDROXIDE, AND GYPSUM OBTAINED FROM DOLOMITE

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Abstract. The results of scanning electron microscopy analysis of dolomite, brucite, magnesium hydroxide and gypsum were studied. This analysis was obtained using the energy dispersive X-ray spectroscopy method and provides information about the chemical composition of the sample. The scanning electron microscopy image shows the morphology and surface structure of the particles in the sample.

Keywords: dolomite, brucite, magnesium hydroxide, gypsum, SEM, EDS, X-ray, research.

Dolomite, $CaMg(CO_3)_2$, is a naturally occurring carbonate mineral that is widely used in various industrial processes and can be used to produce industrial products. Recent experiments have shown that dolomite-derived products such as brucite, magnesium hydroxide, and gypsum are widely used in various industries[1]. The physicochemical properties of these compounds, especially their microstructure and morphology, determine their applications. Scanning electron microscopy (SEM) is currently one of the main analytical tools in modern materials science, providing in-depth studies of the surface, morphology, and particle size of materials. High-resolution images obtained using SEM allow us to identify microscopic changes occurring on the surface of materials.

In this study, brucite, magnesium hydroxide, and gypsum extracted from dolomite were analyzed using SEM to study their morphological properties, crystal structure, and particle size. Based on the results of this analysis, an important scientific basis is created for the practical application of the materials in industry. The quality indicators of products obtained as a result of complex processing of local raw dolomite are also highlighted[2].

By comprehensively studying the technologies for obtaining chemical compounds based on local raw materials, we are working on the creation of completely new substances and materials with predetermined properties based on them, the development of new technological processes that meet the requirements of modern production, and the improvement of existing ones. The technology for the laboratory separation of magnesium oxide and magnesium hydroxide by the decomposition of dolomite in the Dekhkanabad deposits in sulfuric acid is presented, and the physicochemical properties of the obtained raw materials are studied.

Initially, an aqueous solution of sulfuric acid of a certain concentration is placed in a reactor with a silicate enameled interior and a mixing device, and crushed dolomite in the recipe amount is fed into the operating mixer through a ribbon feeder at a certain time. Dolomite and 20-30% sulfuric acid are placed in the mixer and mixed thoroughly for 2 hours. In this process, the ratio of solid and liquid substances is of great importance. In all known technologies, it is the hydromodule unit that differs from each other, and this value is set separately for different raw materials.

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Figure 1. Magnesium hydroxide samples isolated in laboratory conditions from Dehqanabad dolomite

The results of the analysis show that the brucite obtained by the decomposition of dolomite with sulfuric acid consists mainly of magnesium hydroxide. If the amount of magnesium oxide is calculated from 82.0% and sulfur (VI) oxide is 2.20%, it is clear that the product obtained is a mixture of magnesium hydroxide and magnesium sulfate salt. That is, magnesium sulfate contains 82.0% magnesium oxide and 2.2% sulfur oxide, 0.021% chlorine and 0.015% copper oxide.

This analysis was obtained using energy dispersive X-ray spectroscopy (EDS) and provides information about the chemical composition of the sample. Scanning electron microscopy (SEM) images show the morphology and surface structure of the particles in the sample[3].

In this method, the sample under study is examined in a microscope with an electron beam and the intensity of the quanta emitted from the sample is measured[4]. The working principle of SEM is as follows; electrons emitted from an electron gun are accelerated to energies of 2-40 keV; a set of magnetized lenses and scanning sections generate a small diameter electron beam that is placed in a raster on the surface of the sample. When this surface is irradiated with electrons, three types of radiation are excited; reflected or backscattered electrons, secondary electrons, and X-rays. Compared with optical microscopes, it is characterized by high spatial resolution and depth of field, as well as the ability to perform chemical analysis based on recording the radiation spectrum generated when the surface of the sample is irradiated with an electron beam[5]. The study consisted of studying the SEM image and elemental analysis of dolomite using a scanning electron microscope. The SEM image and elemental composition of dolomite are shown in Figure 2.

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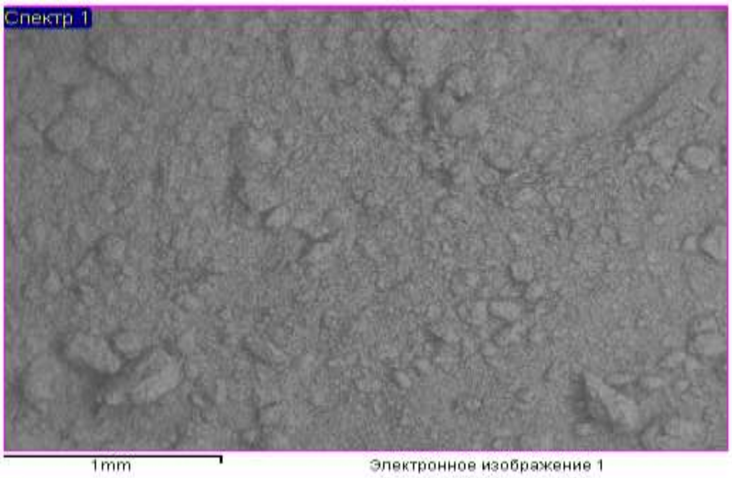
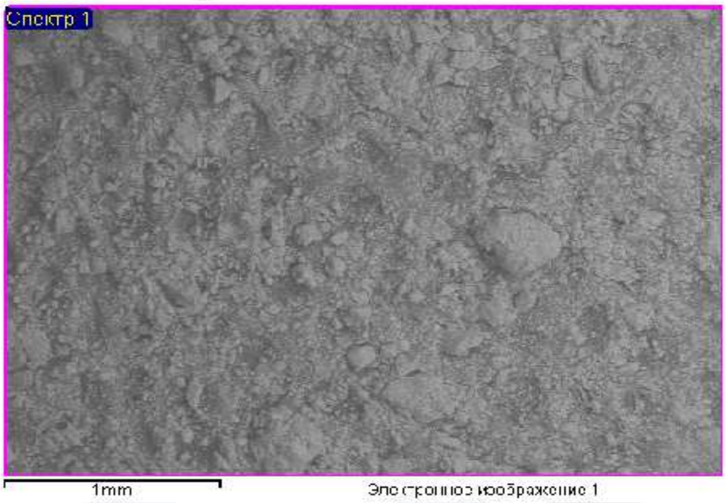


Элемент	Весовой %	Молярный %
C	11.39	17.71
O	53.75	62.73
Mg	10.59	8.14
Al	0.22	0.16
Si	0.32	0.22
Ca	23.72	11.05
Итоги	100.00	

Figure 2. SEM image and elemental analysis of dolomite.

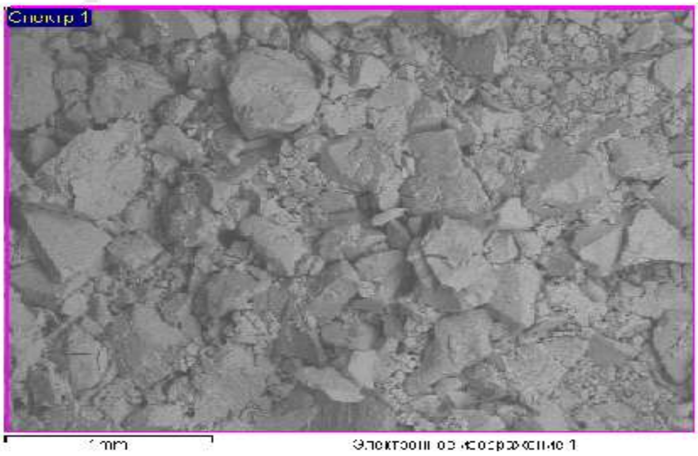
The study consisted of SEM image and elemental analysis of brucite using a scanning electron microscope. The SEM image and elemental composition of dolomite are presented in Figure 3.



Элемент	Весовой %	Молярный %
C	14.28	20.24
O	55.23	58.77
Mg	28.32	19.97
Al	0.42	0.27
Si	0.49	0.30
S	0.58	0.31
Fe	0.47	0.14
Итоги	100.00	

Figure 3. SEM image and elemental analysis of brucite.

The study consisted of studying the SEM image and elemental analysis of magnesium hydroxide using a scanning electron microscope. The SEM image and elemental composition of magnesium hydroxide are presented in Figure 4.



Элемент	Весовой %	Молярный %
C	6.13	9.15
O	56.76	63.61
Mg	36.39	26.84
S	0.72	0.40
Итоги	100.00	

Figure 4. SEM image and elemental analysis of magnesium oxide.

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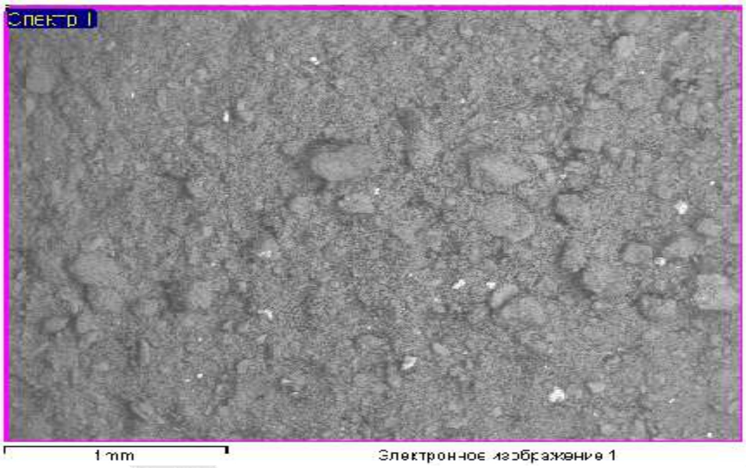
The study consisted of studying the SEM image and elemental analysis of gypsum using a scanning electron microscope. The SEM image and elemental composition of gypsum are presented in Figure 5.



Элемент	Весовой %	Молярный %
C	11.52	18.01
O	53.01	62.23
Mg	8.93	6.90
Al	0.30	0.21
Si	0.53	0.36
S	2.22	1.30
Ca	23.49	11.00
Итоги	100.00	

Figure 5. SEM image and elemental analysis of gypsum.

The results of SEM-EDS analysis of dolomite, brucite, magnesium hydroxide and gypsum show the following main conclusions about their composition, morphology and practical significance[3]. In this case, the lower content of Ca (23.72%) and Mg (10.59%) in the EDS data of dolomite ($CaMg(CO_3)_2$) compared to the theoretical values indicates the influence of calcium-magnesium exchange processes or impurities (Al, Si, Fe) in the mineral.

Brucite ($Mg(OH)_2$) has a lower Mg to O ratio than the theoretical value, which is due to the inability of the EDS method to detect hydrogen. Impurities such as S (0.58%) and Fe (0.47%) indicate the presence of sulfides under hydrothermal conditions. The sharp decrease in S in gypsum ($CaSO_4 \cdot 2H_2O$) is explained by the loss of sulfate during sample preparation or the limited sensitivity of EDS. Mg (8.93%) and Al/Si impurities compromise the purity of the sample. Impurities (Al, Si, Fe, S) detected in SEM-EDS analyses are related to the geochemical conditions of the sample or the preparation process. Additional analyses (e.g. XRD) are recommended to clarify the results[6].

Due to the high carbon monoxide content of dolomite from the Dekhkanabad deposit, the effect of the duration of the decomposition process and the speed of the mixer on the foaming process at a temperature of 20-50°C, a sulfuric acid concentration of 30%. and a level of 100% of the stoichiometric required amount was studied. It was found that with an increase in the duration of the process, the foam ratio passes the maximum level in 25-30 seconds at 750 rpm. With an increase in the speed of the mixer to 1000 rpm, the maximum values of the foam ratio are observed after 20 seconds. The maximum foam coefficient is 8.37-10.22. At the same time, the stability of the foam does not exceed 60 seconds.

Rheological properties of dolomite decomposition products with sulfuric acid. Viscosity, density, crystallization temperature are the most important properties of liquid fertilizers. In order to select a technological scheme and equipment, as well as to determine the suitability of existing equipment for the production of nitrogen-calcium fertilizers, it is necessary to know the rheological properties of the resulting decomposition mixtures, solutions and suspensions [7].

Table 1 shows the dependence of the density and viscosity of the acid slurry obtained as a result of the decomposition of dolomite with sulfuric acid at concentrations of 100-115% and 40-57.5%. The optimal decomposition temperature is 40°C. As can be seen from the data in Table 1, the density of acid slurry at a temperature of 20°C is 1.213-1.418 g/cm3. The density of the solutions decreases

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uniformly with increasing temperature. At a temperature of 60°C, the density is 1.195-1.397 g/cm3, depending on the sulfuric acid standard. The dependence of the density on temperature is linear. With an increase in the average temperature by 10°C, the density decreases by 0.38 (0.33)%.

Moreover, this indicator is practically unchanged for all used concentrations of sulfuric acid. The density increases with increasing sulfuric acid concentration. On average, with an increase in sulfuric acid concentration by 10%, the density increases by an average of 8.45 (6.81)%.

With an increase in the concentration of sulfuric acid from 40 to 50%, the density increases by an average of 7.63 (6.15)%, and with an increase in the concentration of sulfuric acid from 50 to 60%, by 9.26 (7.45)%. It should be noted that this indicator changes slightly with a change in the standard of sulfuric acid.

Table 1

Rheological properties of dolomite solution decomposed by sulfuric acid after decomposition

Normality of H_2SO_4%	Density, g/cm³					Viscosity, mPa·s				
	20 °C	30 °C	40 °C	50 °C	60 °C	20 °C	30 °C	40 °C	50 °C	60 °C
S										
S										
S										
Sulfuric acid concentration – 60%										

Viscosity, the viscosity of solutions in the range of the studied standards and concentrations of sulfuric acid, is from 9.69 to 54.24 mPa•s. With increasing temperature, the viscosity of solutions decreases. With an increase in temperature by 10°C from 20 to 30°C, viscosities decrease by 18.28 (14.73)%, from 30 to 40°C - by 15.85 (12.77)%, from 40 to 50°C - by 13.90 (11.20))%, from 50 to

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60°C - by 12.44 (10.03)%, which is consistent with the well-known ideas about the viscosity of solutions[8].

Thus, the study of the rheological properties of the slurries after disintegration shows that they all have satisfactory mobility and can be easily transported by pumps.

The dependence of the density and viscosity of the precipitated sulfuric acid extract is shown. As a result of studies, the density of solutions at a temperature of 20 ° C is 1.182-1.354 g / cm3. With increasing temperature, the density of solutions decreases uniformly. The dependence of density on temperature is almost linear. On average, with an increase in temperature by 10 ° C, the density decreases by 0.37 (0.30)% [9].

As in acid slurries, the density of the precipitated solutions increases with increasing sulfuric acid concentration. On average, with an increase in sulfuric acid concentration by 10%, the density increases by 7.58 (6.11)%. In addition, with an increase in sulfuric acid concentration from 40 to 50%, the density increases by an average of 6.72 (5.42)%, and with an increase in sulfuric acid concentration from 50 to 60%, it increases by 8.44 (6.80)%. The viscosity of the solutions in the range of sulfuric acid standards and concentrations studied is 2.690-4.391 mPa·s. The viscosity of the precipitated sulfuric acid extract decreases with increasing temperature[10]. With an increase in temperature by 10°C from 20 to 30°C, the viscosity decreases by 18.30 (14.75)%, from 30 to 40°C - by 15.81 (12.74)%, from 40 to 50°C - by 13.95 (11.24))%, from 50 to 60°C - by 12.44 (10.03)%. The viscosity increases with an increase in the concentration of sulfuric acid. On average, with an increase in the concentration of sulfuric acid by 10%, the viscosity increases by 29.37 (23.67)%. In addition, with an increase in sulfuric acid concentration from 40 to 50%, the viscosity increases by an average of 21.50 (17.33)%, and with an increase in sulfuric acid concentration from 50 to 60%, it increases by 37.24 (30.02)%[11].

Thus, the study of the rheological properties of precipitated sulfuric acid extracts showed that they have excellent fluidity and do not require special equipment for pumping them through pipes.

In conclusion, the study clearly demonstrated the effectiveness of the SEM-EDS method in the rapid and qualitative analysis of mineralogical materials, as well as the influence of sample purity and preparation methods on the results.

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