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Karakalpakstan Bentonite Clays - Perspective Raw Materials for Obtaining Ceramic Heat-Insulating Materials

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***Abstract**: The article presents the results of a comprehensive study of bentonite clays of the North Jamansay deposit of Karakalpakstan for the production of ceramic heat-insulating materials. The possibility of using this bentonite clay as a result of studying their chemical and mineralogical, fractional compositions and physico-chemical characteristics for ceramic heat-insulating materials for various purposes has been established.*

***Keywords** : heat-insulating, ceramics, raw materials, bentonite, clay, composition, chemical, X-ray phase, mineralogical, physico-chemical characteristics, swelling.*

I. INTRODUCTION

The strategic focus of the development of thermal insulation materials requires new radical approaches and solutions to their production technology. The predominance of lightweight structures predetermines a low specific consumption of raw materials, and as a result, a low specific energy consumption of production and a significant reduction in heat consumption during the operation of buildings. Thermal insulation products currently consumed are produced mainly from raw materials that are located outside the regions and require transportation to the places of production and consumption, which significantly increases the cost price. Therefore, the development of new compositions of heat-insulating materials from local mineral raw materials, including from industrial wastes, in particular opoka, tripoli, diatomites, ashes, slags, sludge, gas cleaning dust, is of particular relevance. Such materials are products made by swelling of the raw material with pore-forming and burnable additives. In Uzbekistan, due to the rapid development of chemical and other industries and the growth of housing construction, the need for ceramic insulation materials is steadily increasing. They are delivered by rail in a different region, which leads to a significant increase in the cost of this non-transportable product. In this regard, obtaining ceramic insulating materials based on local raw materials and secondary resources is an important task.

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II. RESULTS AND DISCUSSION.

This paper presents the results of a study of bentonite clays of the North Jamansay field of Karakalpakstan to obtain ceramic granules, claydite. In addition, the prospects for the industrial use of bentonite clays in order to obtain from them thermal insulating ceramic granules are not fully appreciated, although they are very interesting and their prospects are obvious.

It is known [1,2] that bentonites and bentonite clays, consisting mainly of the minerals of the montmorillonite group $Al_2[Si_4O_{10}](OH)_2 \cdot nH_2O$ and capable of swelling during firing, can serve as a raw material for the production of expanded clay gravel.

It should be noted that ceramic granules are environmentally friendly insulating materials, which are lightweight, porous materials of a cellular structure in the form of balls of various sizes, obtained by burning bentonite clays that can swell when they are rapidly heated to a temperature of 1050-1300°C during 25-45 min [3-5]. Clay of the North Jamansay field is located in Beruni district, 20 km south-east of the village of Karatau and 9 km south-east of the railway station Karauzak, representing polymineral rock [6,7].

In appearance, this rock is light brownish yellow in color, and in its mineralogical composition, montmorillonite is hydromica.

At interaction of 10% solution of hydrochloric acid, clay boils. The refractoriness of the investigated clay belongs to the group of low-melting raw materials.

According to the content of coloring oxides in the calcined state, the North Jamansay clay belongs to the group with a high content of coloring oxides.

The number of plasticity of the studied samples of the North Jamansay clay is about 14-30 (at Atterberg), therefore, the clay belongs to the moderately plastic group of raw materials.

According to the sensitivity coefficient, clay belongs to the insensitive group of raw materials and, according to the Chizhs CSF, is 0.413. The thickness of the clay of the North Jamansay field varies from 5 to 24 m.

The chemical composition of the clay of the North Jamansay field taken from various sites is given in Table 1.

Table 1
The chemical composition of the studied clay minerals

Number of samples	The content of oxides in% of air dry matter											LOI
	SiO_2	Al_2O_3	Fe_2O_3	FeO	TiO_2	CaO	MgO	K_2O	Na_2O	SO_3	P_2O_5	
NJ-1	60,85	16,95	4,92	1,34	0,79	0,58	1,67	1,65	2,54	0,51	0,09	8,98
NJ-2	60,60	16,06	4,39	1,80	0,77	0,90	1,85	1,53	2,70	0,96	0,12	8,48
NJ-3	59,80	15,22	4,48	1,54	0,81	1,16	1,91	1,58	2,68	0,39	0,11	9,37
NJ_{mid}	60,41	16,07	4,60	1,56	0,79	0,88	1,81	1,59	2,64	0,62	0,11	8,94

Note: Loss on ignition (PPP) includes: hygroscopic, constitutional, crystallized water, organic and volatile substances, and carbon (II) oxide.

The results of the comparison of chemical compounds, in particular the content of silica, alumina, oxides of iron, calcium, alkali metals, carbonates and indicators of loss on ignition (LOI) with the necessary requirements can be noted that this clay rock is suitable for obtaining expanded clay insulating materials.The requirement for clay raw materials by chemical composition for the production of ceramic granules [8] and the indicators of the studied clay raw materials are given in Table 2.

Table 2
Comparative indicators on demand chemical composition to raw materials and the studied clay

Oxide name	The content of oxides in clay rocks with a degree of expansion, in wt.%			Sample rates
	high	medium	weak	NJ_{mid}
SiO_2	50-60	60-70	>70	60,41
Al_2O_3	16-24	10-16	<10	16,07
Fe_2O_3 + FeO	6-10	4-6	<4	6,16
Na_2O + K_2O	3-6	1,5-3	<1,5	4,23
CaO	3-4	3-4	>4	0,88

As can be seen from the data of tables 2, judging by the number of basic oxides of the studied bentonite clay of the North Jamansay deposit, it can be stated that they are indicators of the degree of expansion related to clayey rock with a high degree of expansion. Since, in addition to calcium oxide, the content of basic oxides is within the requirements for clayey raw materials.

It should be noted that the clay rocks used as raw materials for the preparation of expanded clay should have a finely dispersed structure, a relatively small dustiness - no more than 26%; contain particles up to 0,005 mm - not less than 20%; the softening interval must be at least 50 °C; refractoriness not higher than 1350°C, not to have inclusions of carbonate rocks in the form of nodules; loss on ignition 6-10%.

In addition, the main requirement, which must meet the raw materials for the production of expanded clay, is the ability to swell during heat treatment in the temperature range from 1050 to 1250°C and at the same time to give a cellular material with evenly distributed closed pores.

Table 3 shows some of the most important physicochemical properties of bentonite clay from the North Jamansay deposits, which predetermine their potential use as the main raw material component for the production of ceramic heat-insulating materials.

Table 3
Physico-chemical and technological indicators North Jamansay clay

Oxide name	The content of oxides in clay rocks with a degree of expansion, in wt.%			Sample rates
	high	medium	weak	NJ_{mid}
SiO_2	50-60	60-70	>70	60,41
Al_2O_3	16-24	10-16	<10	16,07
Fe_2O_3 + FeO	6-10	4-6	<4	6,16
Na_2O + K_2O	3-6	1,5-3	<1,5	4,23
CaO	3-4	3-4	>4	0,88

The microstructure of the samples and the morphology of the crystalline phases of samples of samples of bentonite clays of the North-Jamansay deposit were carried out on a MBS-10 laboratory optical microscope with a digital camera installed up to x600 magnification (Figure 1). Microscopic studies mainly revealed alkaline and alkaline-earth montmorillonites in the form of aggregated particles of a smaller size, as well as in the form of lumpy aggregates. The presence of amorphous silica is also observed in the form of particles of carbonates and dolomites in the form of white spots. Also found were large, wiry inclusions of iron and quartz compounds, as well as plaster inclusions in the form of crystals of two-water gypsum, which are evenly distributed in the test samples under study.

Figure 1. Bentonite clay of the North Jamansay deposits in the form of clay powder x600

The phase composition of the studied raw materials was determined by X-ray. Identification of samples of studies based on diffractograms, which were filmed on a XRD-6100 apparatus (Shimadzu, Japan), computer-controlled. CuKα-radiation (β-filter, Ni, 1.54178 mode of current and voltage of the tube 30 mA, 30 kV) and a constant rotational speed of the detector of 4 degrees / min with a step of 0.02 degrees were used. (ω / 2θ coupling), and the scanning angle changed from 4 to 80 °. In the calculations and in the identification of the phases, tables and an international card file for X-ray powder patterns [9, 10] were used. The figure 2 shows the radiograph of the original bentonite clay of the North Jamansay field. As can be seen from the X-ray phase studies of experimental samples of raw samples of the North Jamansay clay, the presence of diffraction maxima related to quartz minerals is established - d = 0.427; 0.335; 0.181; 0.157 nm; feldspar -d = 0.325; 0.321 nm; illita - d = 0,495; 0.377; 0.334; 0.323 nm; montmorillonite - d = 0,448; 0.325; 0,258; 0.199; 0.167 nm; high-alumina form of montmorillonite - beidelite - d = 0.725; 0.363; 0.229 nm; dolomite - d = 0,290; 0.180 nm, and calcite - d = 0.495; 0.377; 0.334; 0.318; 0.245 nm.

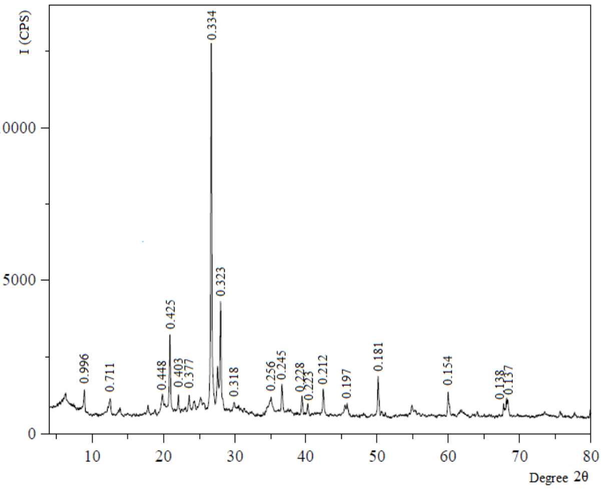

Figure 2. X-Ray diffraction of bentonite clay of the North Jamansay field

Thermal analysis was recorded on a Hungarian Paulik-Paulik-Erdey derivatograph with a speed of 10 K/min and a weighted portion of 0.093 g with sensitivity of the T-900, TG-200, DTA-1/10, DTG galvanometer - 1/10. Recording was performed under atmospheric conditions. The holder was a platinum crucible with a diameter of 10 mm without a lid. Alumina was used as a reference.

Differential-thermal analysis of bentonite clays of the North Jamansay field shows ten endothermic effects at temperatures of 90, 110, 147, 167, 329, 335, 378, 400, 428, 477°C and four exothermic effects at temperatures of 205, 440, 565, 625°C. Endothermic effects at a temperature range of 90-167°C correspond to the removal of water from the interlayer structure of bentonite clays. Endoeffects at a temperature range of 329-477°C correspond to the removal of hydrated water and the decomposition of structural hydroxyl groups and their transition to the anhydrous state.

The exothermic effect at a temperature of 250-440°C shows the burning of organic inclusions in the rock of bentonite clays. The exoeffect at a temperature of 565°C is the removal of water of crystallization and the decomposition of the structure of montmorillonite. The exoeffect at a temperature of 625°C corresponds to the recrystallization of amorphous decomposition products present in the composition of bentonite clays. In this case, the total mass loss in the temperature range 70-900°C according to the thermogravimetry curve is 3.92%.

III. CONCLUSION.

Based on a comprehensive study, chemical-mineralogical and fractional compositions, X-ray diffraction, differential-thermal, microscopic characteristics of bentonite clays of the North Dzhamansay field of Karakalpakstan were studied to obtain ceramic insulation materials. It has been established that the studied bentonite clays are suitable for the production of ceramic heat-insulating materials for various purposes in terms of physicochemical properties and technological parameters.

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Z.R. Kadyrova, born in 1955, higher education, in 1977 she graduated with honors from the Chemical Engineering Department of the Tashkent Polytechnic Institute, with a degree in industrial engineering.

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Doctor of Chemical Sciences. In 2000 she defended her doctoral dissertation in the specialty 05.17.11 - Technology of silicate and refractory non-metallic materials on the topic: "Crystallization of melts, solid-phase synthesis and phase relationships of aluminates and gallates of alkaline earth metals and their solid solutions."

She developed the scientific, theoretical and physico-chemical bases of ceramic, refractory, glass, binders and high-temperature oxide materials, and also recommended the introduction of import-substituting compositions and technologies for producing silicate materials, in particular building ceramics, household porcelain, Portland cement, and refractory materials based on local raw materials and waste industry.

She successfully completed the International Scientific and Technical Grant for the Production of Transparent Ceramics jointly with the Russian State Optical Institute. By publishing scientific articles in prestigious journals in the USA, Germany and the CIS, as well as participating in reports at conferences, it contributes to the growth of the international level of scientific research and development by scientists of Uzbekistan and the scientific potential of the republic. For 17 years she has been the head of a number of State grants.

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