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Justification of the opportunities of obtaining silicate materials based on clay waste adsorbents

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Abstract. The physicochemical composition of the used waste clay adsorbents was studied to justify the possibility of obtaining other silicate new products, and it was found that they did not differ from the original ones. It was determined that the chemical composition of all samples met the requirements for porous materials. It was determined that bentonites have the highest rate of increase. Keywords: clay adsorbent, waste, mineral, disposal, pore, proliferation, dispersion, expanded clay.

1 Introduction

Today, with the extensive development of the construction industry in the republic, the demand for materials in this field is also increasing. With the increase in demand for construction materials, one of the urgent tasks is to find local raw material reserves or to expand the raw material base by utilizing industrial waste to expand production capacity. Several resolutions and decrees of the President have been issued to address these challenges, with particular attention paid to the disposal of more industrial waste. Today, heat-insulating materials are widely used in the construction industry. The application of industrial waste for producing these materials has a positive impact on improving the ecological state of the environment, as well as reducing the cost of production.

According to [1-5], porous heat-insulating silicate materials are widely used today as they reduce heat loss and noise from the building. Also, the best insulating material should have low density and mechanical strength. Ceramic heat-insulating materials based on clay minerals are the most effective. The various methods and technologies create the possibility of controlling the porosity of the obtained heat-insulating materials.

It is known [6-8] that the physical and mechanical properties of building materials directly depend on the chemical and mineralogical composition of raw materials. Bentonite

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and bentonite clays containing montmorillonite ($Al_2[Si_4O_{10}](OH)_2 \cdot nH_2O$) with high expansion properties can be used for obtaining heat-insulating materials.

2 Methods

Clay adsorbents used by oil refineries were used as objects, that is, based on bentonite and opoka clays. Their chemical composition [9], the granulometric composition according to GOST 32026-2012, and mineralogical composition [10] were determined.

3 Results and discussion

Considering this, adsorbents obtained based on clay minerals have the potential to receive heat-insulating materials in the silicate sector.

Table 1. Chemical composition of adsorbents.

The name of the sorbent	**Components name, %**										
	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	п.п.п.
Zikeyv opoka clay soil	69.1	-	15.7	5.55	<0.1	0.02	0.90	1.60	0.15	0.55	4.64
Zelenka opoka	68.5	-	17.2	6.84	<0.1	0.02	1.72	4.84	0.4	0.40	-
Simferopol bentonite	47.3	0.60	16.2	4.46	0.68	0.06	3.74	5.22	1.25	1.65	18.57
Pakistani bentonite	50.0	0.88	16.8	5.32	0.29	0.06	3.03	2.54	1.62	2.01	17.11

Table 1 shows the chemical composition of the adsorbents used, and their chemical composition almost does not change after paraffin and oil purification. It was found that approximately 50% of paraffin and oils are absorbed in the composite of the used sorbents compared to the mass of the sorbent. It is known from the literature [11,12] that combustible (pore-forming) substances are added to create pores in the production of heat-insulating materials. Paraffin and oils in the used adsorbents also serve as inflammable substances and help enhance physical-mechanical and technological indicators of the finished product.

There are particular requirements for the initial raw materials for obtaining heat-insulating materials [13-17], which are listed in Table 2 below.

Table 2. Comparative requirements for raw materials for obtaining porous materials.

Name of oxides	**Degree of abundance and mass of oxides in clay minerals quantity, %**			**Sample pointers**			
	high	**average**	**low**	**Zik. transparent**	**Zelenka opoka indicator**	**Sim. bento$_p$**	**Pure. Bento.**
SiO_2	50-60	60-70	>70	76.0	70.0	47.3	50,0
Al_2O_3	16-24	10-16	<10	5.7	7.2	16.2	16.8
$Fe_2O_3 + FeO$	6-10	4-6	<4	<0.1	<0.1	4.46	5.32
$Na_2O + K_2O$	3-6	1,5-3	<1,5	0.7	0.85	2.9	3.63
CaO	3-4	3-4	>4	1.6	4.8	5.22	2.54

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Comparative indicators (from Table 1) showed that sample 1.2 has a low content of silica and alumina, iron, calcium, alkali metals and carbonates according to Table 2, while sample 3.4 has a high content of chemical composition shows that it can be. As a result of the study of the chemical composition of the used sorbents, it is indicated that porous silicate materials can be obtained from them.

The mineralogical composition of the studied samples was studied using X-ray phase analysis (Fig. 1). The obtained results are mainly d/n = (0.334; 0.424; 0.245; 0.228; 0.224; 0.212 nm) quartz and anorthite belonging to the feldspar group and a small amount of albite d/n = (0.459; 0.409; 0.323; 0.318; nm) minerals showed that it consists of the corresponding diffraction lines.

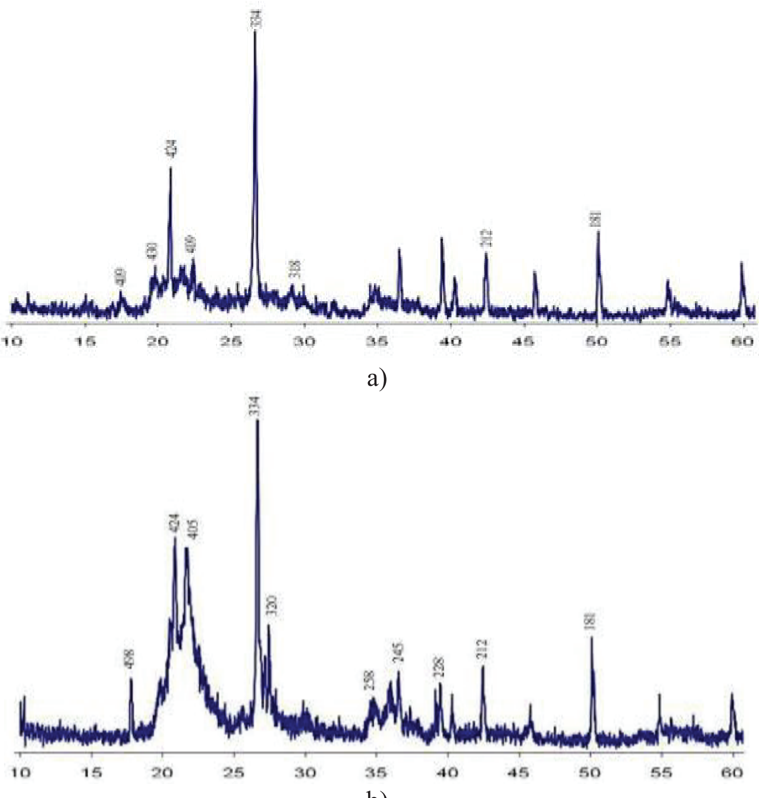

Fig. 1. X-ray image of Zikeev opoka (a) and Zelenka opoka (b).

Diffraction maxima of bentonites in the sample, i.e. d= 0.427; 0.334; 0.181; 0.157 nm quartz minerals; d= 0.325; 0.321 nm feldspar; d= 0.495; 0.377; 0.334; 0.323 nm illite; d=0.448; 0.325; 0.258; 0.199; 0.167 nm montmorillonite; d= 0.996, 0.711; 0.363; 0.229 nm high-glaucous montmorillonite - beidelite form; d= 0.290; 0.180 nm dolomite and d= 0.495; 0.377; 0.318; 0.245 nm is seen to consist of calcite.

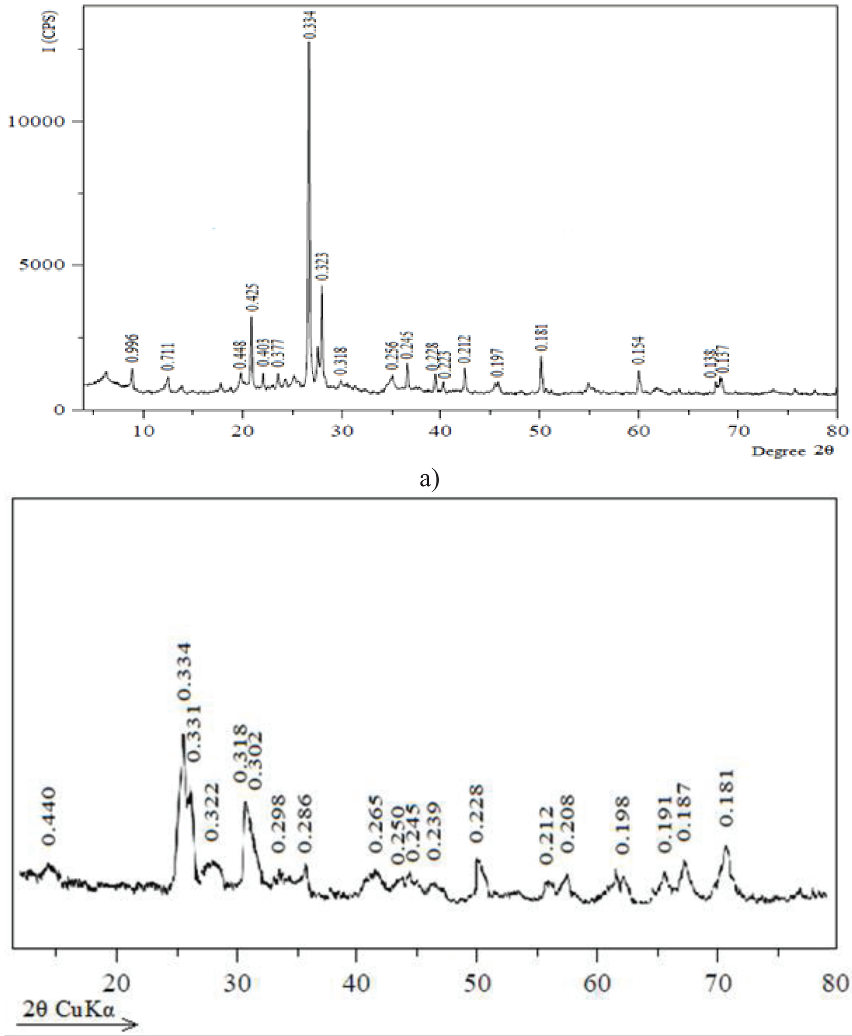

Fig. 2. Radiograph of Simferopol bentonite (a) and Pakistani bentonite (b).

Because physicochemical processes in the production of silicate materials, specifically expanded clay, take place mainly at high temperatures, their DT analyses were performed up to 1000 °C and the obtained results are presented in Figure 3 below.

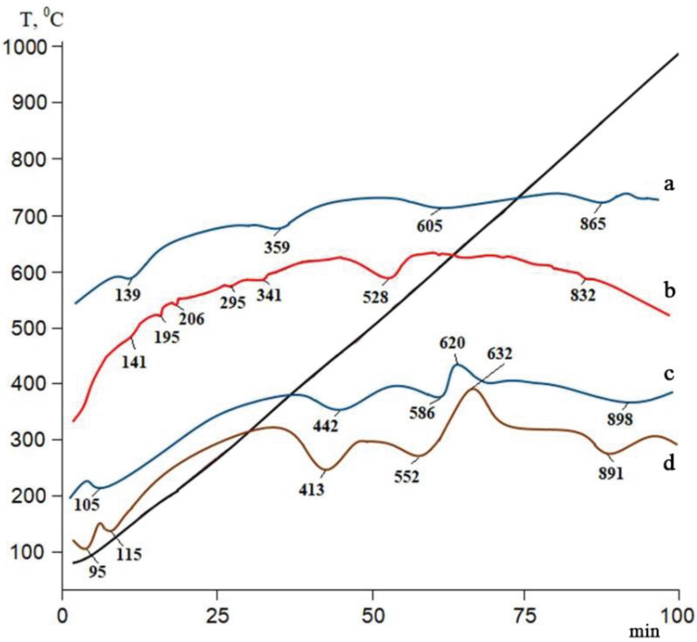

Fig. 3. Results of DT analysis of samples**.** a) Bentonite of Simferopol; b) Bentonite of Pakistan; c) Zelenka opoka; g) Zikeev opoka.

The results of differential thermal analysis of Simferopol bentonite showed the presence of only 4 endothermic effects (Fig. 3a). Here, it is explained by the decomposition process of physically, adsorbed and chemically bound water at temperatures of 139, 359, 605 °C, and at 865 °C, SO_2 in the composition. In Pakistani bentonite (Fig. 3b), effects at temperatures of 141, 195, and 206 °C showed that physically bound waters decompose a little slower than Simferopol bentonite, and effects at 295, 341 °C showed that adsorptive bound waters decompose at slightly lower temperatures. And the end effect in Pakistani bentonite at a temperature of 528 °C is formed as a consequence of energy absorbed in the release of chemically bound waters from the mineral montmorillonite.

The results of DT analysis showed that this process also occurred in Simferopol bentonite. The effect at the temperature of 832 °C with low intensity formed during the decarbonization process of calcite mineral, which is present in a small amount in the composition.

The results of the differential thermal analysis of the Zelenka furnace (Fig. 3c) show 4 endoeffects at temperatures of 105, 442, 586 and 898 °C and an exoeffect at 620 °C, and in the analysis of the Zikeev furnace (Fig. 3d) endoeffects at temperatures of 95, 115, 413, 552, 891 °C and an exoeffect at 632 °C showed its existence. Here, too, endoeffects are formed in the processes of decomposition and decarbonization of bound waters. Exoeffects at temperatures of 620 and 632 °C, respectively, are explained by the recrystallization of β-quartz into α-quartz in opoka.

Thus, as a result of physical-chemical analysis, chemical-mineralogical and granulometric, X-ray phase, and differential-thermal analysis, the used samples of opoka and bentonite can be considered as a suitable material for making silicate expanded clay.

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