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RESEARCH ARTICLE

INFLUENCE OF DIATOMITE ON THE FIRING PROPERTIES OF WALL CERAMICS

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Abstract. *The article presents the results of a study on the use of diatomite in ceramic mixtures for the production of high-efficiency wall ceramics. It was established that diatomite samples contain both micro- and mesopores, as well as H3-type hysteresis loops, which confirm their high porosity. The average pore sizes were determined to be 1.5 nm for micropores and 4.4 nm for mesopores. The study identified the main patterns of change in the physical and mechanical properties of ceramic samples depending on the diatomite content at a firing temperature of 1000 °C. Increasing the diatomite content to 50% (by reducing the clay content to 50%) led to a significant decrease in average density and compressive strength. The average density decreased from 1.8 g/cm³ to 1.23 g/cm³, while the compressive strength decreased from 15.2 MPa to 9.6 MPa. At the same time, the total porosity of the samples remained at approximately 53%. A considerable reduction in the thermal conductivity coefficient– from 0.8 to 0.31 W/(m·°C). A comparative analysis of the physical and mechanical properties of the studied ceramic compositions with those of ceramics based on pure clay revealed substantial differences across all property indicators. The samples produced from the modified ceramic composition exhibited a lower average density and more than twice the overall porosity. It was determined that ceramic samples fired at 1000 °C form a sintered microporous structure characterized by low average density, reduced thermal conductivity, and satisfactory compressive strength and water absorption values.*

Keywords: *diatomite, ceramic masses, porosity, thermal conductivity, density, strength.*

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ДИАТОМИТТІҢ ҚАБЫРҒА КЕРАМИКАСЫНЫҢ КҮЙДІРУ ҚАСИЕТТЕРІНЕ ӘСЕРІ

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Аңдатпа. *Мақалада тиімді қабырға керамикасын алу үшін керамикалық массалар құрамында диатомитті қолдану бойынша зерттеу нәтижелері келтірілген. Диатомит үлгілерінде микро және мезопоралар бар екендігі анықталды, сонымен қатар жоғары кеуектіліктің дәлелі болып табылатын Н3 типті гистерезис ілмектері бар. Микропоралардың орташа мөлшері -1,5 нм, мезопоралар-4,4 нм. Күйдіру температурасы 1000 0С кезінде диатомиттің құрамына байланысты керамикалық үлгілердің физика-механикалық қасиеттерінің өзгеруінің негізгі заңдылықтары анықталды. Саздың 50% - ға дейін төмендеуіне байланысты диатомиттің 50% - ға дейін жоғарылауы орташа тығыздықтың айтарлықтай төмендеуіне және қысу беріктігінің төмендеуіне әкелді. Орташа тығыздықтың төмендеуі 1,8 г/см3-тен 1,23 г/см3-ке дейін, ал қысу беріктігінің төмендеуі 15,2 МПа-дан 9, 6 МПа-ға дейін. Бұл жағдайда үлгілердің жалпы кеуектілігі 53% деңгейінде сақталады. Жылу өткізгіштік коэффициентінің көрсеткіштерінің төмендеуі де 0.8-ден 0.31 Вт/м 0С-қа дейін маңызды). Таза саз негізіндегі керамикалық үлгілермен салыстырғанда керамикалық массалардың зерттелетін құрамдарының үлгілерінің физика-механикалық қасиеттерінің өзгеруін салыстырмалы талдау барлық қасиеттер көрсеткіштері бойынша айтарлықтай өзгерістерді көрсетті. Зерттелетін керамикалық массаға негізделген үлгілер орташа тығыздықтың төмендеуіне және жалпы кеуектіліктің 2 еседен астам жоғарылауына ие. 1000 0С температура интервалында күйдірілген керамикалық үлгілер орташа тығыздығы төмен, жылу өткізгіштік коэффициенті және сығымдау мен суды сіңіру кезінде қанағаттанарлық беріктік көрсеткіштері бар агломерацияланған микрокеуекті сынық болып табылатыны анықталды. Диатомитті қолдану дайын өнімнің беріктік көрсеткіштерін сақтай отырып, диатомит сияқты жоғары кеуектілікті қамтамасыз етпейтін арнайы күйдіретін қоспаны енгізуді болдырмауға мүмкіндік береді.*

Түйін сөздер: *диатомит, керамикалық массалар, кеуектілік, жылу өткізгіштік, тығыздық, беріктік.*

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НАУЧНАЯ СТАТЬЯ

ВЛИЯНИЕ ДИАТОМИТА НА ОБЖИГОВЫЕ СВОЙСТВА СТЕНОВОЙ КЕРАМИКИ

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Аннотация. *В статье представлены результаты исследования по использованию диатомита в составе керамических масс для получения эффективной стеновой керамики. Установлена, что в образцах диатомита имеются как микро, так и мезопоры также имеются петли гистерезиса Н3 типа, что является доказательством высокой пористости. Средний размер микропор составляет -1.5 нм, мезопор – 4.4нм. Установлены основные закономерности изменения физико-механических свойств керамических образцов в зависимости от содержания диатомита при температуре обжига 1000 0С. Увеличения содержания диатомита до 50% за счет уменьшения содержания глины до 50% привели к значительному снижению средней плотности и снижению показателей прочности при сжатии. Снижение средней плотности составляет от 1,8 г/см3 до 1,23 г/см3, а снижение предела прочности при сжатии составляет от15,2 МПа до 9, 6 МПа. При этом общая пористость образцов сохраняется на уровне 53%. Снижение показателей коэффициента теплопроводности также значительны от 0.8 до 0.31 Вт/ м 0С). Сравнительный анализ изменения физико-механических свойств образцов исследуемых составов керамических масс по сравнению с керамическими образцами на основе чистой глины показали существенные изменения по всем показателям свойств. Образцы на основе исследуемой керамической массы обладает пониженной средней плотностью и повышенной общей пористостью более чем 2 раза. Установлено, что керамические образцы, обожженные в интервале температур 1000 0С представляют с собой спеченный микропористый черепок обладающими низкими показателями средней плотности, коэффициента теплопроводности и удовлетворительными показателями прочности при сжатии и водопоглощения. Использование диатомита позволяет исключить введение специальной выгорающей добавки, которые не обеспечивает столь высокую пористость как диатомит при сохранении прочностных показателей готового продукта.*

Ключевые слова: *диатомит, керамические массы, пористость, теплопроводность, плотность, прочность.*

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CONFLICT OF INTEREST

The authors state that there is no conflict of interest.

The authors declare that no generative artificial intelligence technologies or AI-based tools were used in the preparation of this article.

АЛҒЫС / ҚАРЖЫЛАНДЫРУ КӨЗІ

Зерттеу жеке қаржыландыру көздерін пайдалана отырып жүргізілді.

МҮДДЕЛЕР ҚАҚТЫҒЫСЫ

Авторлар мүдделер қақтығысы жоқ деп мәлімдейді.

Авторлар мақаланы дайындау барысында генеративті жасанды интеллект технологиялары мен жасанды интеллектке негізделген технологияларды пайдаланбағанын мәлімдейді.

БЛАГОДАРНОСТИ/ИСТОЧНИК ФИНАНСИРОВАНИЯ

Исследование проводилось с использованием частных источников финансирования.

КОНФЛИКТ ИНТЕРЕСОВ

Авторы заявляют, что конфликта интересов нет.

Авторы заявляют о том, что при подготовке статьи не использовались технологии генеративного искусственного интеллекта и технологии, основанные на искусственном интеллекте.

1 INTRODUCTION

The demand for energy-efficient construction materials has stimulated extensive research into lightweight wall ceramics with improved thermal insulation performance. Conventional ceramic bricks, despite their durability and fire resistance, are often characterized by relatively high density and thermal conductivity, which limits their application in energy-saving building envelopes. One of the most effective approaches to improving the thermal performance of ceramic materials is the formation of a porous structure, which reduces bulk density and heat transfer while maintaining sufficient mechanical strength through controlled sintering processes (**Bordia et al., 2017; Dal et al., 2020; Galán-Arboledas et al., 2017; Pimraksa & Chindaprasirt, 2009**).

Naturally porous mineral additives have attracted increasing attention as alternatives to conventional pore-forming agents. Diatomite, a biogenic siliceous material with low intrinsic density and a highly developed micro- and mesoporous structure, has demonstrated strong potential for the production of lightweight ceramic materials. Previous studies have shown that incorporating diatomite into clay-based ceramic bodies can significantly reduce density and thermal conductivity and modify firing behavior, although the final properties strongly depend on composition and processing conditions (**Dal et al., 2020; Galán-Arboledas et al., 2017; Pimraksa & Chindaprasirt, 2009**). Despite these advances, the influence of diatomite content on the firing properties and performance of wall ceramics requires further investigation. Therefore, the present study aims to evaluate the effect of diatomite addition on the firing behavior and key physical and thermal properties of wall ceramics fired at 1000 °C.

2 LITERATURE REVIEW

Actions in the fields of climate, environmental protection, and the efficient use of raw materials and resources represent some of the most significant challenges facing modern society. Against this background, the construction sector must adapt to new materials and systems to ensure environmentally sustainable development (**Moldamuratov et al., 2022, 2023; Zhakipbayev et al., 2025**). This requires research aimed at minimizing energy consumption in new buildings while also reducing energy use in existing structures subject to renovation (**Alhazmi & Anand, 2025; Nazari et al., 2025**).

Various researchers have studied the physical, mechanical, and thermal properties of bricks incorporating waste materials such as agricultural residues, paper, wood, plastics, ash or slag, sludge powder, or dried sludge from wastewater treatment plants (**Ediz et al., 2010; Vasconcelos et al., 1998**). Many of these studies have focused on increasing porosity as a means of producing thermally insulating ceramic materials.

The successful development of the construction industry is closely linked to the production of high-performance wall ceramics. The key measures for enhancing the efficiency of wall ceramics include reducing density and thermal conductivity by increasing the porosity of the ceramic body and the hollowness of products, improving mechanical strength, accelerating technological processes, and reducing production costs (**Ibraimbayeva et al., 2023; Zhapakhova et al., 2023**).

Materials exhibiting these properties belong to the LEEENDT class (lightweight, eco-friendly, economical, non-combustible, durable, and technologically advanced). It should be noted that in the near future, ceramics with such unique characteristics are expected to play a leading role in sustainable construction (**Baidrakhmanova et al., 2023; Yestemessova et al., 2023**).

In the production of ceramic materials, achieving these properties is possible through the formation of a porous ceramic structure. Solving this problem requires the development of innovative technologies for new ceramic compositions that utilize non-traditional raw materials to achieve both resource and energy savings–not only during production but also throughout the material's service life.

Enhancing the thermal insulation properties of building envelopes is among the most pressing tasks in modern materials science. This challenge is directly related to the development of new raw material compositions aimed at producing structural and insulating materials with improved thermal performance (**Dos Reis et al., 2020**).

Recently, there has been a sharp increase in demand for new energy- and resource-efficient porous and hollow ceramic materials that significantly reduce raw material consumption and energy costs during drying and firing. The challenge of developing such materials lies in adapting modern technologies to locally available raw materials, as well as the absence of clear criteria for raw material selection and established scientific and technological foundations for their production.

In developed countries, increasing the porosity of ceramic materials has made it possible to substantially reduce their average density and achieve thermal conductivity values as low as 0.14–0.18 W/(m·°C).

The characterization of pore structure in ceramics commonly involves parameters such as total porosity, open and closed porosity, capillary and permeable porosity, effective and channel porosity, tortuosity and structural factors, pore size and distribution, mean pore diameter, specific surface area, gas permeability, and water permeability. Among these, porosity, pore shape, and pore size are of primary importance. In ceramic materials, pore sizes can vary widely–from fractions of a nanometer to several millimeters.

A considerable number of studies in various scientific and industrial fields have addressed porosity. However, the mechanisms of pore formation and the final structure of porosity in building ceramics remain insufficiently studied (**Barbieri et al., 2013**).

One promising approach to addressing this issue is the use of siliceous rocks such as diatomite and tripoli, which are abundant in the western regions of the Republic of Kazakhstan. Owing to their unique properties, siliceous rocks are increasingly used in the production of building materials, as sorbents for water purification (**Bilgin et al., 2012; Gao et al., 2025**), and in veterinary applications for the production of bioactive feed additives with therapeutic and preventive effects (**Brodskii & Urbakh, 1976; Brodskiy & Urbakh, 1977; X. Huang et al., 2025**).

In (**Chojnacka, 2010)**, the main aspects of producing artificial ceramic binders (ACB) based on natural (quarry) and heat-treated diatomite were examined. The process of obtaining ACB was investigated, and its rheological and physico-mechanical properties were analyzed. It was established that ACB derived from raw diatomite exhibits thixotropic rheological behavior, while ACB obtained from heat-treated diatomite demonstrates thixotropic-dilatant characteristics. Implementing such a production technology can reduce molding moisture during the manufacturing of diatomite-based products and improve their quality while decreasing production costs compared to traditional methods.

Other studies (**Peretokina et al., 2023**) have reported the use of diatomite in producing heat-resistant ceramic concretes. Thus, extensive scientific and practical research is being conducted worldwide on the application of diatomite in various industries due to its unique properties. As a result, diatomite-based materials are successfully utilized in many countries for the production of diverse products. However, in Kazakhstan, diatomite remains insufficiently studied for the development of high-efficiency building materials.

Therefore, the aim of this study is to establish the scientific foundations for producing efficient wall ceramics by incorporating diatomite into clay-based compositions.

3 MATERIALS AND METHODS

For the scientific and experimental research, the raw materials used included clay from the Pogodayev deposit in the West Kazakhstan region and diatomite from the “Zhalpak” deposit in the Aktobe region.

To determine the local elemental composition of the raw material samples, scanning electron microscopy (SEM) was employed using a JSM-6390LV microscope equipped with an energy-dispersive microanalysis system. The chemical elemental composition was analyzed using inductively coupled plasma mass spectrometry (ICP-MS) with an Agilent 7500cx spectrometer. The mineralogical composition was determined by X-ray diffraction (XRD) analysis using an X'Pert PRO

MPD diffractometer, while phase composition studies were performed with a DRON-3 X-ray diffractometer.

Thermal conductivity of the ceramic samples was measured using the ITP-MG-4 “ZOND” thermal conductivity analyzer. The porosity and micro-/mesopore characteristics of the diatomite samples were investigated using a high-performance 3Flex automated gas sorption analyzer (Micromeritics, USA). Prior to measurement, all samples were degassed on a SmartVacPrep system (Micromeritics, USA) equipped with a fore-vacuum pump under the following conditions:

– Temperature 90 °C for 60 min;
– Temperature 180 °C for 1200 min;
– Pressure < 0.02 Torr.

After degassing, the samples were weighed to account for mass loss and then subjected to additional surface purification on the 3Flex-e analyzer under the following conditions:

– Temperature 180 °C for 600 min;
– Pressure < 0.00004 Torr.

Analysis of the obtained pore structure data revealed that all adsorption isotherms correspond to Type IV, indicating the presence of both micro- and mesopores. Additionally, the occurrence of H3-type hysteresis loops was observed, which is characteristic of aggregates of plate-like particles forming slit-shaped pores.

Based on the results, it can be concluded that the diatomite samples contain both micro- and mesopores, along with H3-type hysteresis loops–evidence of high porosity. The average pore sizes were determined as 1.5 nm for micropores and 4.4 nm for mesopores.

In its natural form, the clay from the Pogodayev deposit appears as dark gray fragments. Its greasy texture to the touch indicates high plasticity. Compared with tripoli (opaline rock), this clay exhibits a denser structure. However, the fracture surfaces show intergranular macropores (**Figure 1, Table 1**).

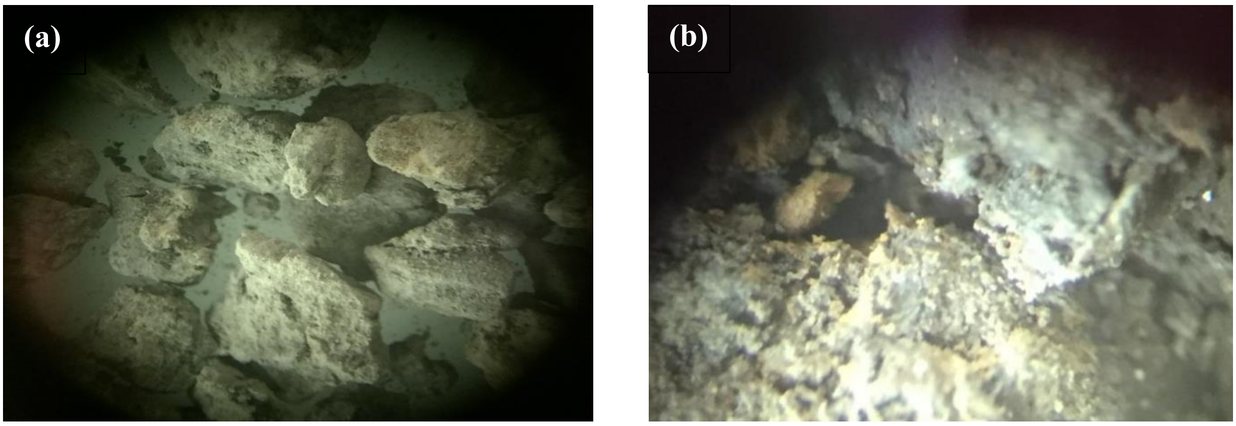

Figure 1 – Crushed particle morphology and macroporous structure of montmorillonite clay from the Pogodayev deposit: (a) crushed clay particles (particle size 10–25 mm); (b) macroporous structure of the clay in fracture view (magnification ×50) (authors material)

Table 1
Chemical composition of clay from the Pogodayev deposit

Name of raw material	**Oxide content, wt.%**							
	SiO2	Al2O3	CaO	MgO	Fe2O3	SO3	Na2O	Impurities
Clay – Pogodayev deposit	61,51	17,06	2,27	3,21	6,36	1,27	3,57	6,75

The microstructure, spectra, and chemical elemental composition of the montmorillonite clay from the Pogodayev deposit are presented in **Figure 2** and **Table 2**.

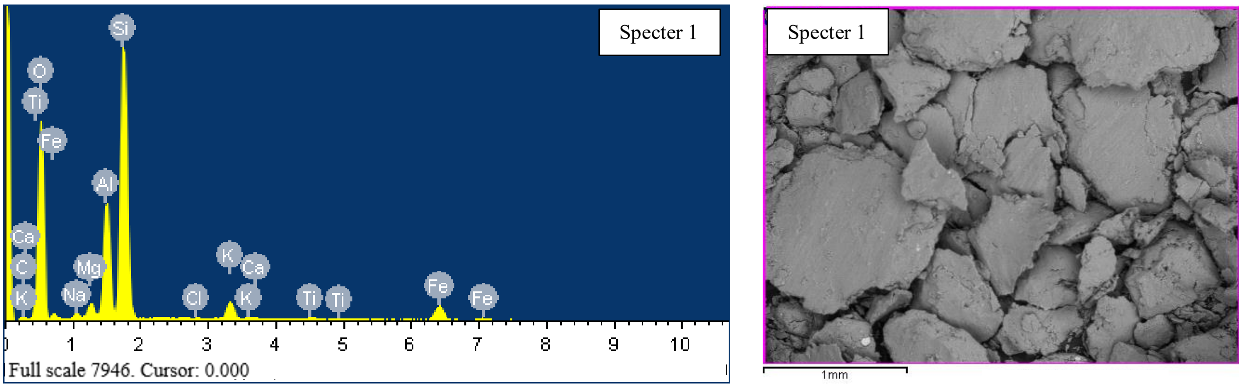

Figure 2 – Microstructure and spectra of the clay from the Pogodayev deposit (authors material)

Table 2

Chemical elemental composition of montmorillonite clay from the Pogodayev deposit (authors material)

Name of chemical elements	C	O	Na	Mg	Al	Si	S	K	Ca	Ti	Mn	Fe	Total
Content, %	9.47	48.22	0.68	1.25	9.10	22.85	0.23	2.10	0.21	0.65	0.49	5.39	100

According to the results of X-ray phase analysis (XRD) (**Figure 3**), the mineralogical composition of the clay is predominantly represented by montmorillonite with the following interplanar spacings (d/n = 5.06, 4.46, 3.79, 3.06, 2.45, 2.28, 2.12, 1.97, 1.81, and 1.67 Å). In addition, the clay contains quartz (SiO_2) with d/n = 4.24, 3.34, 2.45, 2.28, 2.12, 1.98, 1.81, 1.66, and 1.33 Å; hematite (Fe_2O_3) with d/n = 2.69, 1.83, 1.68, and 1.59 Å; and hydromica with d/n = 3.21, 2.57, 2.12, and 1.49 Å.

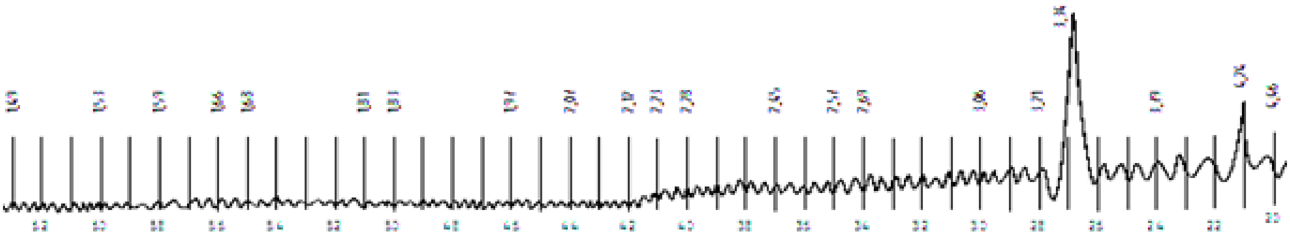

Figure 3 – X-ray diffraction pattern of the clay from the Pogodayev deposit (authors material)

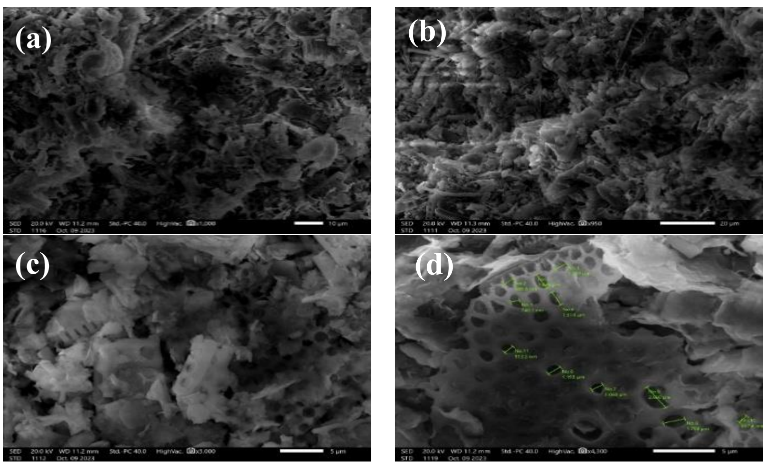

Figure 4 – Porous structure of diatomite from the "Zhalpak" deposit:
(a) magnification ×1000, (b) magnification ×950, (c) magnification ×3000, (d) magnification ×4300 (scanning electron microscope JSM–IT200) (authors material)

It should be noted that microscopic observations (**Figure 4**) indicate that the main mass of the rock is composed of globular opal with a low refractive index, within which clay matter and a small amount of terrigenous impurities are uniformly distributed. In the opaline matrix, organic inclusions are observed, represented mainly by remnants of sponge spicules and diatom algae.

Some diatom shells are well preserved, clearly showing their characteristic cell-like, reticulate structure. Thus, the studied diatomite consists not only of mineral but also of biological components. The biological fraction of the tripoli rock includes sponge spicules and diatoms.

To determine the crystalline phases of the diatomite, X-ray diffraction analysis was performed using a D8 ENDEAVOR diffractometer (Bruker, Germany) within the 2θ range of 8–64° (**Figure 5**).

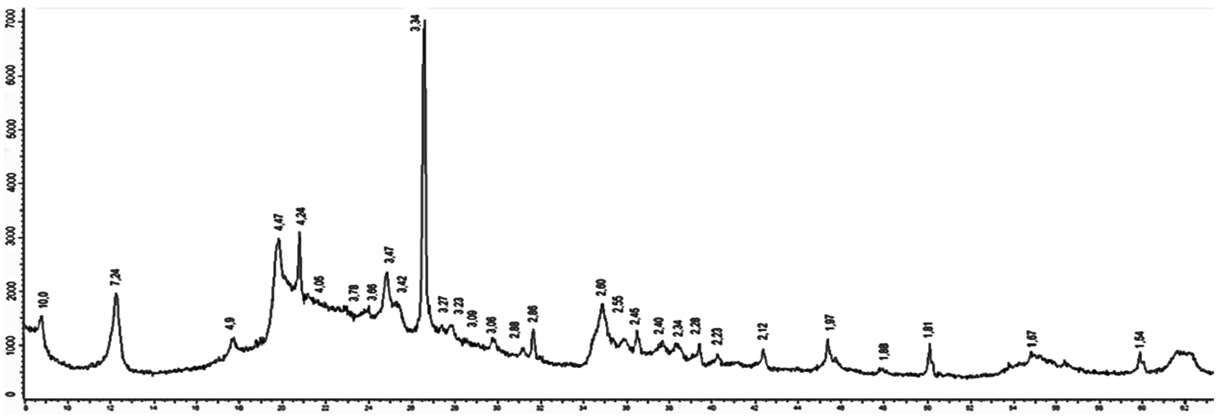

Figure 5 – X-ray diffraction pattern of diatomite from the "Zhalpak" deposit, Aktobe region (authors material)

As a result of X-ray phase analysis, it was established that the diffraction pattern of the raw diatomite (**Figure 2**) shows the most characteristic quartz line with an interplanar spacing of 3.34 Å. Several distinct lines typical of amorphous SiO_2 are also present, with interplanar spacings of 2.55 and 4.24 Å, as well as lines with spacings of 4.47, 4.05, and 3.78 Å, indicating the presence of montmorillonite in the sample.

The obtained results are consistent with findings reported by other researchers, confirming that diatomite is a lightweight, soft, light-colored sedimentary rock composed mainly of siliceous micro-shells of single-celled algae–diatoms–characterized by a wide variety of shapes and sizes, typically ranging from 10 to 200 nm in diameter. The main component of these siliceous shells is amorphous hydrated silica (opal) with varying water content ($SiO_2 \cdot nH_2O$) (**Galal Mors, 2010; Qi et al., 2025; Zhang & Wang, 2006**).

4 RESULTS AND DISCUSSION

For the experimental study, the compositions of the raw material mixtures were selected within the following concentration limits of the components, wt.%: clay – 50–90, diatomite – 10–50. The investigated compositions are presented in **Table 3**.

Table 3
Studied compositions of ceramic mixtures (authors material)

№ Compositions	Name of raw materials	
	Clay	Diatomite
0	100	-
1	90	10
2	80	20
3	70	30
4	60	40
5	50	50

* Note: Composition No. 0 refers to the ceramic sample without diatomite addition.

The preparation of the raw mixture for obtaining the ceramic mass was carried out in the following sequence. Clay and diatomite were first crushed using a laboratory crusher to obtain a particle size of less than 1 mm. The resulting clay and diatomite powders were then weighed according to the studied compositions (**Table 3**) and loaded into a laboratory mixer for dry blending. After achieving a homogeneous mixture, water was added, and the components were thoroughly mixed again to form the ceramic mass.

The molding moisture content of the ceramic mass ranged from 23% to 30% of the dry components' weight. Cylindrical samples with dimensions of 50×50×50 mm were formed from the prepared ceramic mass by plastic molding (**Figure 6**).

Figure 6 – Laboratory green cylindrical samples (authors material)

The molded cylindrical samples were dried in a drying oven at a temperature of 80–85 °C until a residual moisture content of 8–10% was achieved.

The dried (green) cylindrical samples were then fired at a temperature of 1000 °C in a laboratory muffle furnace, with a heating rate of 150 °C per hour. The holding time at the final temperature was 1 hour. After firing, the samples were left in the switched-off furnace to cool naturally to room temperature (**Figure 7**).

Figure 7 – Laboratory heat-treated cylindrical samples at a temperature of 1000 °C (authors material)

The heat-treated cylindrical ceramic samples were subjected to physical and mechanical testing in accordance with standard procedures.

The key physical and mechanical properties selected for evaluation–characterizing the efficiency of the samples–included average density (g/cm³), compressive strength (MPa), water absorption (%), total porosity (%), and thermal conductivity (W/(m·°C)).

For comparative analysis, control samples were simultaneously prepared using ceramic masses composed solely of pure clay without diatomite additives (composition No. 0).

Analysis of the physical and mechanical properties of the samples fired at 1000 °C made it possible to determine the main trends in their variation depending on the component composition within the studied raw material system (**Figure 8**).

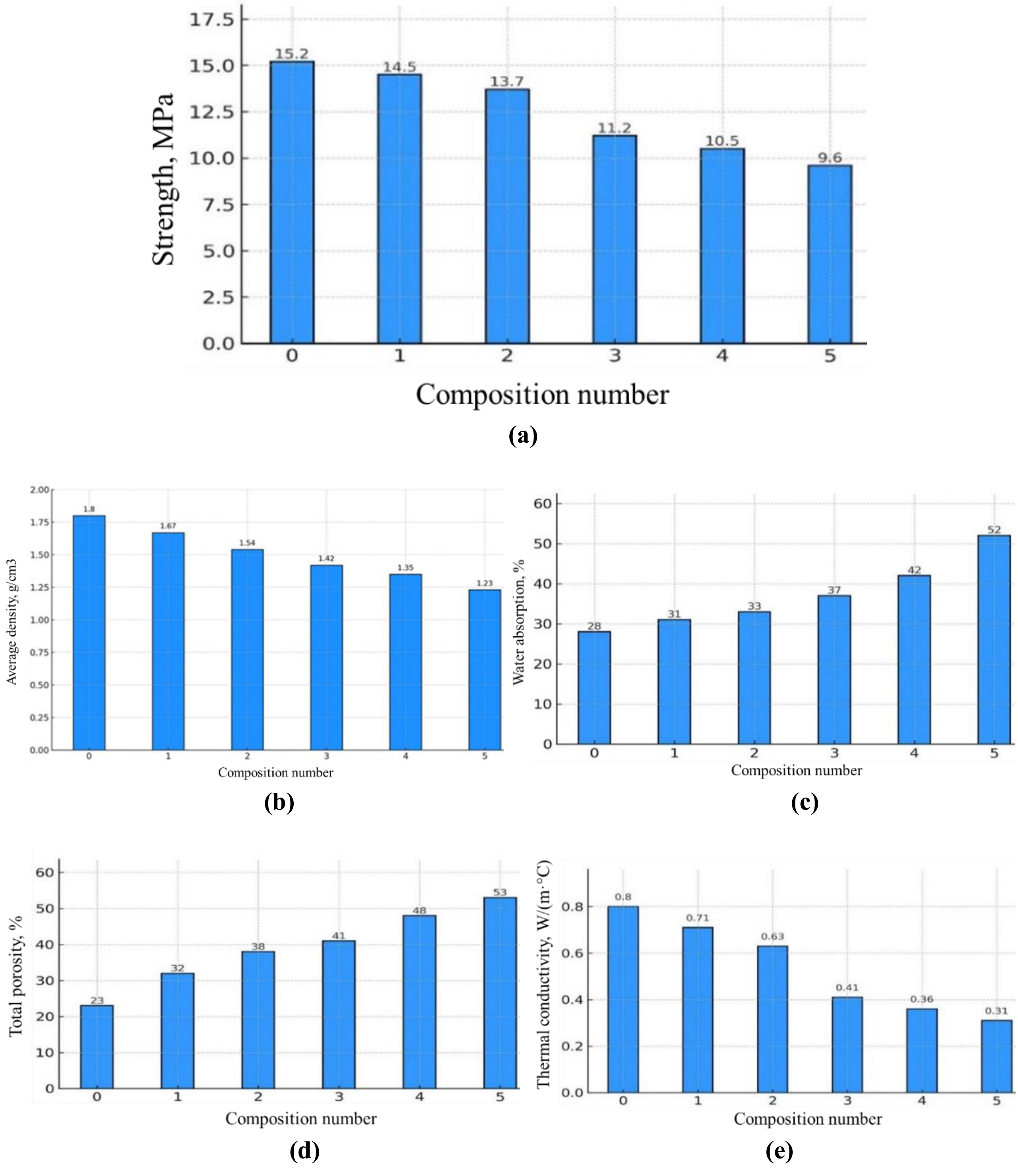

Figure 8 – Dependence of physical and mechanical properties on the composition of ceramic samples fired at 1000 °C: (a) compressive strength (MPa), (b) average density (g/cm³), (c) water absorption (%), (d) total porosity (%), (e) thermal conductivity (W/m·°C) (authors material)

As shown by the obtained results, the lowest values of average density and thermal conductivity coefficient were achieved for composition No. – containing 50% diatomite and 50% clay. In this case, the maximum total porosity reached 53%. It should be noted that despite the high total porosity and low average density, the heat-treated samples exhibited a relatively high compressive strength of 9.6 MPa. The obtained data are consistent with studies conducted by other researchers on the formation of porous structures in ceramic masses using pore-forming additives (**Han et al., 2025; J. Huang et al., 2025**). Increasing the diatomite content to 50% while reducing the clay content to 50% led to a significant decrease in average density (from 1.8 g/cm³ to 1.23 g/cm³) and compressive strength (from 15.2 MPa to 9.6 MPa), while maintaining a total porosity of 53%. The reduction in thermal conductivity was also substantial –from 0.8 to 0.31 W/(m·°C). The increase in total porosity was confirmed by a corresponding rise in water absorption, ranging from 28% to 52%. A comparative analysis of the physical and mechanical properties of the studied ceramic compositions versus those based solely on pure clay revealed significant differences across all parameters: the samples containing diatomite demonstrated more than twice the porosity and lower average density. These effects can be explained by the fact that clay promotes sintering of the ceramic mass, while diatomite, due to its natural structure, contributes to additional pore formation. Thus, as an additive, diatomite imparts lightness and porosity to the ceramic material (**Bao et al., 2024; Labandero et al., 2025**). As a result, the ceramic samples fired at 1000 °C formed a sintered microporous body characterized by low average density, low thermal conductivity, and satisfactory compressive strength and water absorption values (**Figure 9**).

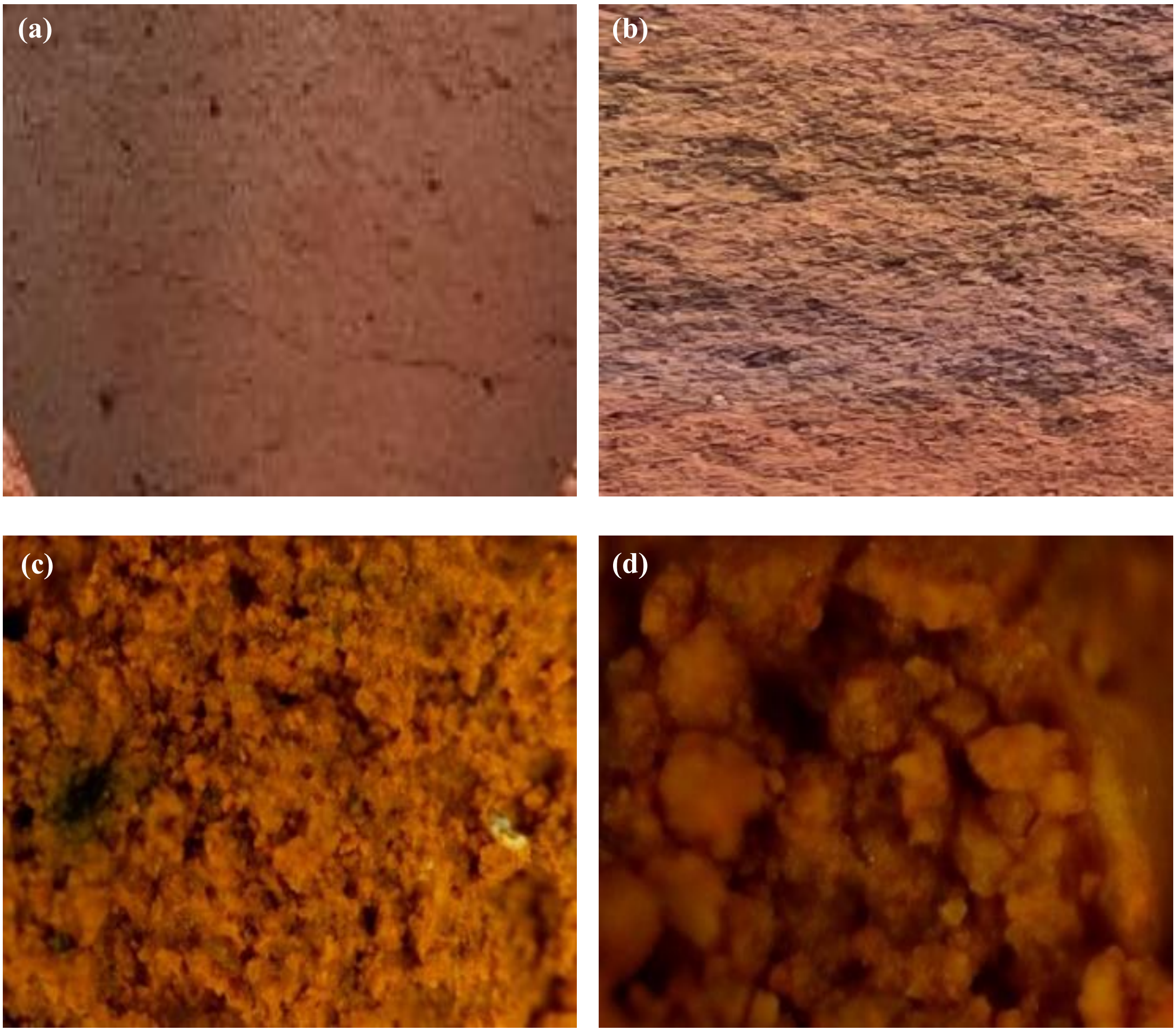

Figure 9 – Macrostructure of the ceramic sample heat-treated at 1000 °C: (a) surface of the ceramic sample (magnification ×10), (b) cross-section of the central part of the ceramic sample (magnification ×20), (c) same central part of the ceramic sample (magnification ×50), (d) same central part of the ceramic sample (magnification ×100) (Levenhuk 320 Series microscope) (authors material)

Under the microscope, both micro- and macropores, as well as intergranular pores, are clearly visible–these are interconnected as a result of the sintering of clay and diatomite. Moreover, the overall porosity is enhanced due to the naturally high porosity of diatomite. It should be noted that, in traditional ceramic brick technology, special combustible additives are typically introduced to achieve porosity and reduce the average density. However, the use of diatomite eliminates the need for such additives, as it provides a much higher level of porosity while maintaining the strength characteristics of the final product.

5 CONCLUSIONS

The present study investigates the potential of diatomite as a functional additive in ceramic compositions for the production of lightweight, energy-efficient wall materials. Diatomite, owing to its highly porous siliceous structure, can significantly influence the microstructural and thermophysical properties of ceramics. The research focused on analyzing the chemical–mineralogical composition and pore characteristics of diatomite, followed by evaluating its impact on the physical, mechanical, and thermal performance of ceramics at various replacement levels of clay. The experimental results provide insights into optimizing diatomite-based formulations to achieve a balance between strength, porosity, and thermal insulation, contributing to the development of advanced porous ceramics for sustainable construction applications.

1 The chemical–mineralogical and porous structure of diatomite was studied to assess its suitability for use in ceramic compositions. It was established that the diatomite samples contain both micro- and mesopores, along with H3-type hysteresis loops, confirming high porosity. The average pore sizes were 1.5 nm for micropores and 4.4 nm for mesopores;

2 The main patterns of variation in the physical and mechanical properties of ceramic samples depending on the diatomite content at a firing temperature of 1000 °C were identified. Increasing the diatomite content to 50% (while reducing the clay content to 50%) led to a significant decrease in average density and compressive strength. The average density decreased from 1.8 g/cm³ to 1.23 g/cm³, and the compressive strength decreased from 15.2 MPa to 9.6 MPa, while total porosity remained at 53%. The reduction in thermal conductivity was also considerable–from 0.8 to 0.31 W/(m·°C);

3 A comparative analysis of the physical and mechanical properties of the studied ceramic compositions versus those based solely on pure clay revealed substantial differences across all parameters. The samples produced from the modified ceramic compositions exhibited lower average density and more than twice the total porosity;

4 It was determined that ceramic samples fired at 1000 °C form a sintered microporous body characterized by low average density, reduced thermal conductivity, and satisfactory compressive strength and water absorption values. The use of diatomite eliminates the need for special combustible additives, which do not provide as high a level of porosity as diatomite, while maintaining the required strength properties of the final product.

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