СТРОИТЕЛЬСТВО И АРХИТЕКТУРА

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THE EFFECT OF ALUMINOSILICATE RAW MATERIALS ON IMPROVING THE QUALITY OF AUTOCLAVE SILICATE MATERIALS

***Abstract**. To improve the physical and mechanical properties of autoclave-treated silicate materials and expand the range of raw materials used, laterite rocks and volcanic ash extracted from deposits in the territory of the State of Eritrea were used in this study. The influence of laterite rocks, volcanic ash and CaO_{act} on the physical and mechanical characteristics of the obtained samples was studied using the experimental planning method. The compressive strength increased significantly with an increase in the volcanic ash content, reaching values of 25 MPa for samples containing 25 wt.% volcanic ash and 8 wt.% lime, which is approximately a 50 % increase compared to the values obtained at 5 wt.% of volcanic ash. When using these compositions, the average density exceeded 1900 kg/m^3, water absorption was 8 wt. %. Silicate materials have high water resistance; the softening coefficient exceeds 0.90. The results obtained also provide a wide selection of compositions based on the studied raw materials with high physical and mechanical characteristics, allowing for consideration of the availability and economic feasibility of the raw materials depending on the required structural integrity. The synthesized neoplasms present in the samples are classified as low-base calcium hydrosilicates CSH(B), in particular alumina-containing tobermorite $C_5S_6H_5$ and hydrogranates of the composition $C_3AS_xH_{(6-2x)}$. Consequently, laterite and volcanic ash provide a high reactivity of the raw material mixture of the $CaO–SiO_2–Al_2O_3–Fe_2O_3–H_2O$ system during autoclave treatment.*

***Keywords**: Laterite, lime, volcanic ash, autoclave treatment, physical andmechanical properties.*

Introduction. The construction industry constitutes a segment of the economy that imposes significant challenges on both the environment and the socio-economic progression of particularly developing nations. Scholarly investigations and technological innovations within the domain of construction materials are directed towards establishing a framework for improving building efficiency, with the ultimate objective of guaranteeing the the long-term sustainability of the construction industry, while considering ecological balance, durability issues, socioeconomic impacts, and cultural factors [1–5].

Adobe bricks are abundantly accessible, economically viable, and environmentally sustainable [6–9]. However, in spite of their numerous advantages, they are frequently considered as a construction option for individuals with limited financial means in Eritrea and many African countries, primarily due to concerns on their inadequate physiomechanical characteristics. This prevailing viewpoint arises from utilization of raw materials without appropriate enhancements. Consequently, comprehensive building codes and regulations governing the application of these natural materials remain insufficiently developed, particularly in the African context.

It is well-established that a prevalent approach for enhancing the composition of lime-silica binders utilized in the production of autoclave materials involves the incorporation of active aluminosilicate constituents into their matrix [1]. The utilization of both natural and industrial aluminosilicate substances exhibiting pozzolanic characteristics is utilized in composite binders, thereby facilitating the activation of chemical interactions among components and decreasing the proportion of quartz in the binder, which is an intensively exploited and depleted resource, in addition to significantly altering the phase composition of the resultant products.

A negligible proportion of the vast reserve of clay rocks present in the Earth's crust has been exploited by the construction sector. Clay minerals, defined as hydrophilic aluminosilicates, exhibit both plasticity and adhesive characteristics upon their interaction with water, subsequently solidifying during the processes of drying or thermal treatment [10–12]. The fundamental composition of clay is primarily constituted of silica, alumina (or magnesia, or both, with a possible substitution for iron), in conjunction with substantial amounts of calcium, potassium, sodium, and various crystalline impurities such as quartz, feldspar, and mica. The ratios of SiO_2, Al_2O_3, Fe_2O_3, MgO, and CaO are instrumental in determining the functional attributes of clay minerals. These minerals display significant physical and chemical reactivity, which can be attributed to their minute particle dimensions, unique crystalline arrangements, high adsorption capacities, and negative surface charges. As a result, they are applicable in various capacities within the construction sector when treated properly.

Laterites represent finely textured soils characterized by a significant concentration of iron oxides, resulting from the extensive weathering of the underlying parent rock formations in humid tropical and subtropical environments [13]. Laterite constitutes a stratified soil comprising the unstable constituents silt and clay and the stable constituents gravel and sand in the presence of moisture, thereby rendering it appropriate for the production of bricks. Such soils exhibit enhanced durability and resistance to moisture infiltration, as well as reduced susceptibility to substantial volumetric variations.

Volcanic activity is prevalent in numerous regions across the globe, and as a result of recurrent volcanic eruptions, volcanic debris are abundantly available. Rocks derived from volcanic processes are of significant interest in the synthesis of silicate materials owing to their intrinsic properties, which encompass components of the active amorphous phase. Volcanic debris encompasses a broad spectrum of applications, particularly in the construction of diverse structural forms, ranging from residential edifices to public infrastructure, attributed to its beneficial characteristics including thermal and acoustic insulation, non-toxicity, fire resistance, an elevated strength-to-weight ratio, moderate elasticity and longevity, as well as a porous configuration with reduced permeability [14–18]. Furthermore, owing to its elevated silica composition, volcanic ash exhibits substantial chemical inertness and remains largely unaffected by the majority of acidic substances. Volcanic ash may serve as a pozzolanic agent provided that the cumulative weight percentage of SiO_2, Al_2O_3, and Fe_2O_3 exceeds 70 wt.%.

Volcanic ash is highly heterogeneous, with significant variability in chemical composition, particle size distribution, and physical properties depending on its source. However, the effectiveness of volcanic ash as a binder or filler material under the conditions typical for autoclaving remains inadequately explored. This variability can complicate standardization processes necessary for its use in autoclave silicate materials. Researchers may be hesitant to explore volcanic ash further without a clear understanding of how these differences affect performance in autoclaved applications.

Despite its prospective applications, laterite has not been extensively studied as a component of autoclave silicate materials. Research in the field of construction materials has predominantly focused on conventional components such as Portland cement, silica sand, and aggregates which may have obscured the exploration of alternative materials, such as laterite.

The primary aim of this investigation is to evaluate physical and mechanical properties of autoclave silicate materials sourced from deposits within the territory of the State of Eritrea, specifically focusing on laterite and volcanic ash, as essential components to enhance the quality of autoclave silicate products. Approximately 33 % of Eritrea's terrestrial land is covered by laterite soil, which exhibits limited economic value. Furthermore, there exists a substantial accumulation of volcanic debris in Eritrea that has yet to be harnessed by the construction industry. Therefore, it is feasible to expand the range of building materials by coordinating the production of silicate materials with the help of these raw materials which beer the essential oxides necessary for hydrothermal synthesis.

Materials and methods. The sand, laterite rocks and volcanic ash used in this study were selected from geological deposits located within the territory of the State of Eritrea. The sand is obtained from the southern administration zone, specifically from locality in proximity to the village of Keih-Kor. The modulus of the sand size is 2,6, which is characterized as course. The sand is extensively employed for construction activity throughout the country.

Laterite was selected from the central administrative zone, specifically from the periphery of the capital city Asmara, known as Borboriela. The predominant compound in laterite is Iron (III) oxide, which comprises 48.4 wt.%, and the rock is distinguished by a leached silica content exhibiting an Al_2O_3/SiO_2 molar ratio higher than the recommended limit to be suitable for autoclave processing unless the ratio is diminished through amalgamation with alternative raw materials. The primary mineral component of the laterite is kaolinite. The laterite is moderately plastic with a plasticity of 10 wt.%.

The volcanic ash is sourced from the Alid mountain range located within the Northern Red Sea administrative zone. This volcanic ash comprises rock that has originated from siliceous lava with a composition of 68.82 wt.% SiO_2, and in contrast to laterite, the volcanic ash is distinguished by a low Al_2O_3/SiO_2 molar ratio. The volcanic ash predominantly exists in an X-ray amorphous phase, exhibiting considerable feldspar inclusions.

The examined raw materials were subjected to pre-drying in a drying cabinet at a temperature of 105 °C until attaining a constant mass, subsequently being pulverized in a vibrating mill to achieve a specific surface area of 240–250 m^2/kg. Quick lime lump was milled to attain a particle size of 400–500 m^2/kg and an activity of 92 %. The method for determining the activity of lime, including measurement of the content of active CaO and MgO, was done in accordance with Russian Standard GOST 22688-2018.

The preparation of the raw material mass involved the meticulous mixing of dry components in predetermined ratios. Initially, laterite, volcanic ash, and lime were comprehensively mixed. Subsequently, the resultant binder was combined with sand and adequately moistened with water, and stored in a hermetically sealed vessel overnight. Following the hydration of the lime from the resultant mixtures, cylindrical samples, each with a diameter and height of 25 mm, were obtained utilizing a hydraulic press under a pressing pressure of 20 MPa.

The autoclave treatment was executed in accordance with the established methodology, as in following regime: the steam pressure within the autoclave was build up over a duration of 1.5 hours, subjected to isothermal conditions for a period of 6 hours, and subsequently, the steam pressure was reduced over a span of 1.5 hours. Ultimately, the samples were assessed for their physical and mechanical properties in compliance with the regulatory standards.

The determination of the mineralogical composition of the samples was executed utilizing the following apparatus: X-ray diffraction analysis was performed employing a DRON-2 diffractometer, while differential thermal analysis (DTA) and thermogravimetric analysis (TG and DTG) were conducted utilizing a NETZSCH STA 449 F3 Jupiter instrument. Additionally, the microstructural characterization of the specimens was undertaken using a TESCAN MIRA 3 LMU scanning electron microscope, which is integrated with a device for performing elemental analysis via energy dispersion spectroscopy (EDS) [19, 20].

The experimental investigations were executed employing the technique of orthogonal central composition planning of the raw material mixture, which incorporates laterite rocks volcanic ash, and active CaO as parameters [21, 22]. In the course of the experiments, all variables x_1, x_2, and x_3 were manipulated across three distinct levels – the central level (0), the lower level (-1), and the upper level (+1), with each level being demarcated from the central level by a differential value of Δx_i (Table 1).

The resilience of the identified functional relationship was assessed through the utilization of the correlation coefficient. Computational analysis of the primary dataset was employed to derive the coefficients of the regression equation along with the physical and mechanical characteristics of the material.

Table 1

Experimental planning conditions

Parameters	Levels of variation			The variation interval
	–1	0	+1	
Laterite content, wt. % (x_1)	10	25	40	15
Volcanic ash content, wt. % (x_2)	5	15	25	10
CaO_{act} content, wt. % (x_3)	6	8	10	2

According to the findings derived from the experimental procedures, calculations were made using the method of mathematical statistics, resulting in equations that encapsulate the correlation between the examined properties and the initial factors. The generated second order regression equations showing the dependence of the physical and mechanical properties (y) on the parameters x1, x2 and x2 is given by:

$$y = b_0 + \sum_{i=1}^{n} b_i x_i . + \sum_{j=i+1}^{n} \sum_{i=1}^{n-1} b_{ij} x_{ij} . + \sum_{i}^{n} b_{ii}(x_{ii}^2 - \bar{x}_i^2) + \varepsilon_{ij}$$

where b_0 is the free coefficient; b_i is the linear regression coefficient; b_{ij} is the regression coefficient with pairwise interactions of the factors; ε is an error term and x_i and x_j are the factors, where n=3 in the current study.

The obtained regression equations showing the dependence of the compressive strength (R_{cm}), mean density (ρ), water absorption (ω), and the softening coefficient (K_s) of the synthesized samples on the concentrations of laterite (x_1), volcanic ash (x_2) and CaO_{act} (x_3) are:

$$R_{cm} = 21{,}883 + 0{,}025x_1 + 3{,}23x_2 - 0{,}085x_3 - 0{,}316x_1^2 - 1{,}411x_2^2 - 2{,}186x_3^2 - 2{,}014x_1x_2 - 0{,}966x_1x_3 + 0{,}519x_2x_3$$

$$\rho = 1922{,}98 - 38{,}4x_1 - 32{,}6x_2 - 32{,}1x_3 - 27{,}29x_1^2 - 3{,}29x_2^2 - 18{,}79x_3^2 - 40{,}88x_1x_2 - 14{,}38\,x_1x_3 - 1{,}13x_2x_3$$

$$\omega = 9{,}96 + 1{,}10x_1 - 0{,}65x_2 + 1{,}24x_3 + 0{,}37x_1^2 + 0{,}65x_2^2 + 0{,}76x_3^2 + 1{,}11x_1x_2 + 0{,}44x_1x_3 + 0{,}11x_2x_3$$

$$K_s = 0{,}8744 - 0{,}008x_1 - 0{,}018x_2 + 0{,}004x_3 + 0{,}0053x_1^2 + 0{,}0053x_2^2 + 0{,}0653x_3^2 - 0{,}0275x_1x_2 - 0{,}0025x_1x_3$$

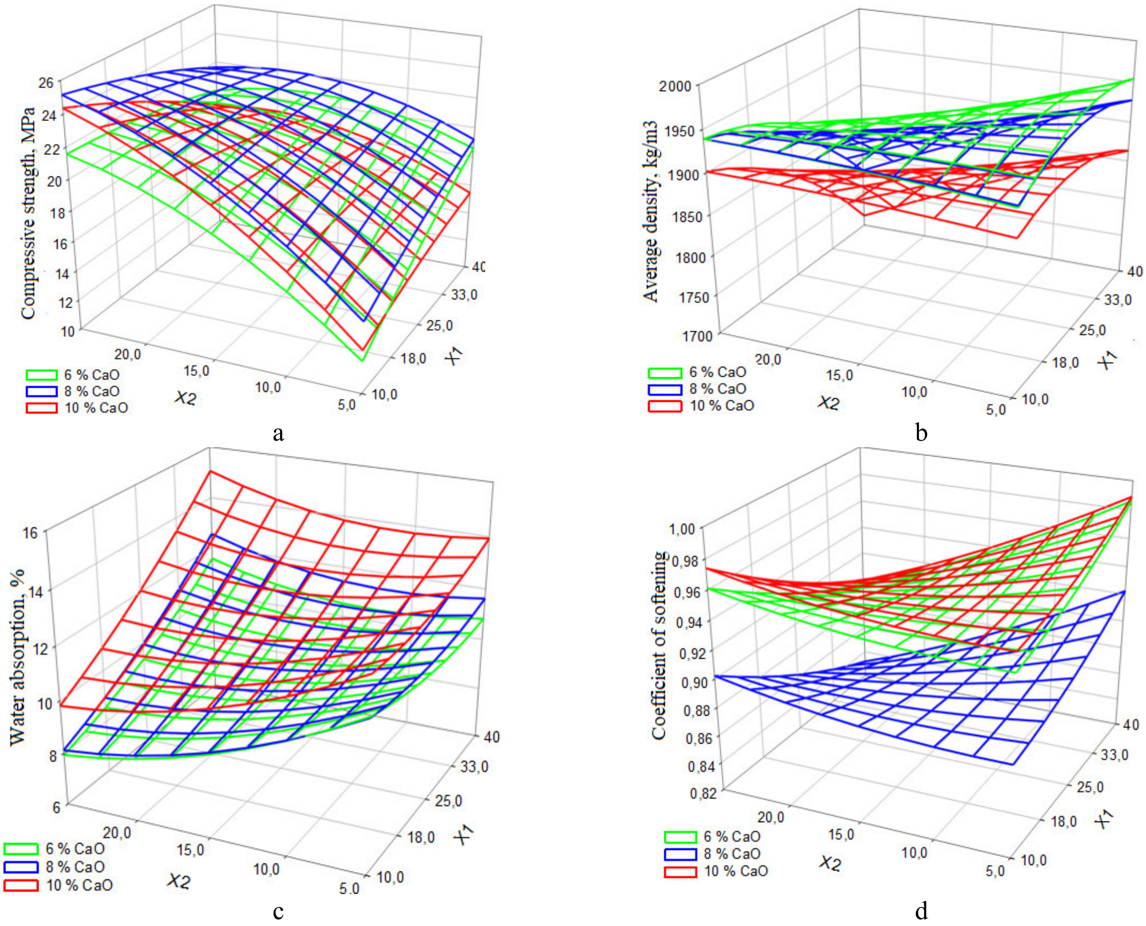
Utilizing the data matrix from the regression equations, graphical representations of the physical and mechanical properties of the specimens were ultimately constructed.

Main part. The dependence of the compressive strength, average density, water absorption and coefficient of softening of the samples on the concentrations of the three factors (laterite, volcanic ash, and CaO_{act}) are illustrated in fig. 1a–1c.

The average dry density of the samples decreased in proportion to the rise in lime content, attributable to the flocculation and agglomeration of clay particles within the soil matrix, which results in an elevation of the void ratio (Fig.1b). The average density exhibits a maximum value in specimens containing a 6 wt.% lime concentration, whereas the curves for specimens with 8 and 10 wt.% lime demonstrate analogous patterns, but at a diminished magnitude. For instance, samples containing 25 wt.% laterite, 15 wt.% volcanic ash, and increasing CaO proportions at 6, 8, and 10 wt.% show a declining average densities of 1936, 1917, and 1864 kg/m³, respectively.

Irrespective of their lime content, the samples demonstrated an elevated density at 10 wt.% laterite and concentrations of volcanic ash ranging from 15 to 25 wt.%. The average density of the samples exhibited a decline as the proportions of volcanic ash increased within the laterite concentrations of 25 to 40 wt.%. Despite the high iron content present in laterite rocks, volcanic ash generally manifests a higher or comparable compacting effect to that of laterite.

The compressive strength of the samples improved significantly at lower concentrations of laterite (10 wt.%), particularly with a lime content of 8 wt.%. The compressive strength reached a value of 25 MPa with a volcanic ash content of 25 wt.%, while the average density of the samples exceeded 1900 kg/m^3, the corresponding water absorption reached a minimum value in 8% by weight, and the softening coefficient exceeded 0.90 (Fig. 1a–1c). The water absorption is inferior and the softening coefficient is superior at 10 wt.% lime content (fig.1c). The reason for the elevated water absorption is associated with the low density of the samples and the reason for increased coefficient of softening with an increase in lime content can be related to the increased reactivity of the siliceous and aluminounous components with calcium hydroxide in the presence of water under hydrothermal conditions. The optimal concentration of active CaO has been determined to be 8 wt.%. The most important characteristics of clay-based building materials, particularly in wet conditions, is the softening coefficient which quantify the resistance of product to moisture.



a b

c d

Fig. 1. Dependence of the compressive strength (a), average density (b), softening coefficient (c) and water absorption (d) on laterite (x_1), volcanic ash (x_2) and CaO contents of the obtained samples

At a laterite content of 25 wt.%, the compressive strength exhibited a positive correlation with the increment of volcanic ash content, ultimately reaching a value of 22.10 MPa at 15 wt.% volcanic ash and 24.11 MPa at 25 wt.% volcanic ash (refer to Fig. 2). In this context, the average density displayed a decreasing trend, reaching 1845 kg/m³ at 25 wt.% volcanic ash. The values for water absorption and softening coefficient were marginally lower than those recorded at the 10 wt.% laterite concentration; nevertheless, the samples remained impermeable and water resistant. The observed reduction in density, while simultaneously upholding adequate compressive strength and water resistance, imparts the benefit of minimizing the dead load associated with building materials, thermal comfort and sound insulation. This phenomenon likely be attributed to hard aggregation of silica, alumina and clay particles, surrounded by cementitious substances which exhibit significant resistance to water penetration, ensuring that the mixture of laterite and volcanic ash demonstrates a degree of insensitivity to moisture.

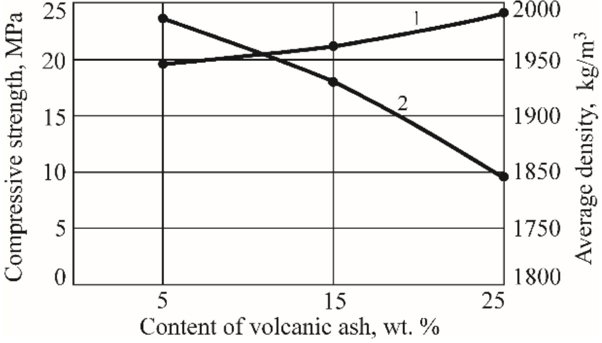


Fig. 2. The dependence (1) compressive strength (2) average density on volcanic ash contents at 25 wt.% laterite and 8 wt.% CaO

At the lowest volcanic ash concentration (5 wt.%), the compressive strength increased notably with an increase in laterite concentration increased, reaching values 18–19 MPa for specimens with 6 and 8 wt.% lime. The specimens with 6 weight percent lime performed best, as evidenced by their 1950 kg/m³ density, less than 11 wt.% water absorption rate, and a softening coefficient approaching unity. 10 wt.% lime has better performance at higher volcanic ash and lower laterite concentrations and 6 wt.% lime yield better results at high laterite and low volcanic ash concentrations, hinting that lime is effectively absorbed by volcanic ash compared to laterite which demonstrates the high reactivity of volcanic ash in the composite raw materials under hydrothermal conditions.

Generally, at the optimum lime content, a compressive strength of 25 MPa at 10 wt.% laterite and 25 wt.% volcanic ash wt.% and a 24 MPa at 25 wt.% laterite and 25 wt.% volcanic ash concentrations are obtained. At 6 wt.% lime, 40 wt.% laterite and 5 wt.% volcanic ash a 19 MPa compressive is obtained. The samples are demonstrated high density and water resistance. The choice depends on the availability and cost of the individual raw materials and the required structural integrity.

The structural properties of the samples were further studied though differential thermal analysis (DTA), x ray powder diffraction (XRD) and electron scanning microscope (ESM) to analyze the phase composition of the synthesized neoplasms and the structure of the formed cementing agents.

The derivatogram data of the samples with a laterite content of 40 wt.%, volcanic ash 25 wt.% and CaO 10 wt.% is shown in Fig.3. A pronounced endothermic effect is observed on the DTA curve of the samples at 81.8 °C, corresponding to the removal of sorption water, which is accompanied by a loss of sample mass (see TG and DTG curves). This probably indicates the presence of slightly crystallized calcium hydrosilicates. The endothermic effect at 320,4 °C and the loss of mass in this case probably refers to the presence of hydrogranates. The slight endothermic effect with mass loss in the studied samples is observed at 514,2 °C, which belongs to unreacted clay minerals. The peak of 574,6 °C corresponds to the polymorphic transformation of quartz. Endothermic effects at 673,9 °C, accompanied by weight loss, probably belong to calcium carbon silicates. Exothermic effects at 929,5 °C indicate the presence of kaolinite in the samples.

Quartz (4.258; 3.346; 1.820 Å) is recorded in the radiographs of the samples comprising 40 wt.% laterite, 25 wt.% volcanic ash, and 10 wt.% CaO (Fig. 4a), as well as samples containing 10 wt.% laterite, 5 wt.% volcanic ash, and 10 wt.% CaO (Fig. 4b). Kaolinite (7.172; 3.581; 2.343 Å) is distinctly identified in samples exhibiting a laterite content of 40 wt.% which indicates unbound clay content at high laterite concentration which demonstrated relatively weak compressive strength and high water absorption. The absence of kaolinite at 10 wt.% laterite indicates the clay content is completely consumed in the process of phase formation.

A diminutive reflex of 2.623 Å, indicative of calcium hydroxide is recorded in the analyzed samples, a finding that is also confirmed by thermal analysis data. It can be inferred that there is no significant unbound calcium hydroxide which implies the process of phase formation occurs with considerable intensity. Both clay minerals and quartz sand exhibit reactivity with calcium hydroxide. The emergence of low-base calcium hydrosilicates is possible in the samples, aligning with a reflex range of 3.03–3.04 Å. Nevertheless, it poses a challenge to definitively ascertain the existence of low-base calcium hydrosilicates through X-ray phase analysis, as this reflection also aligns with calcium carbonate.

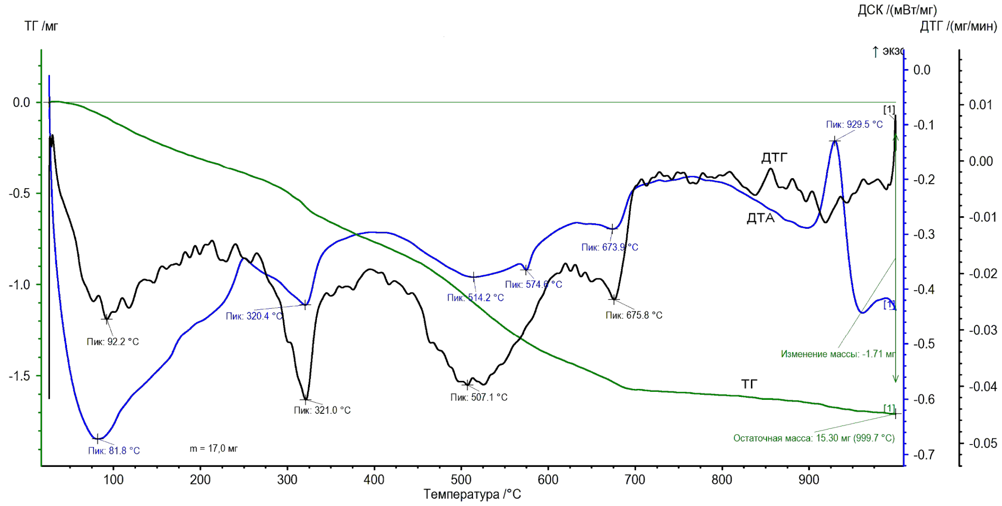
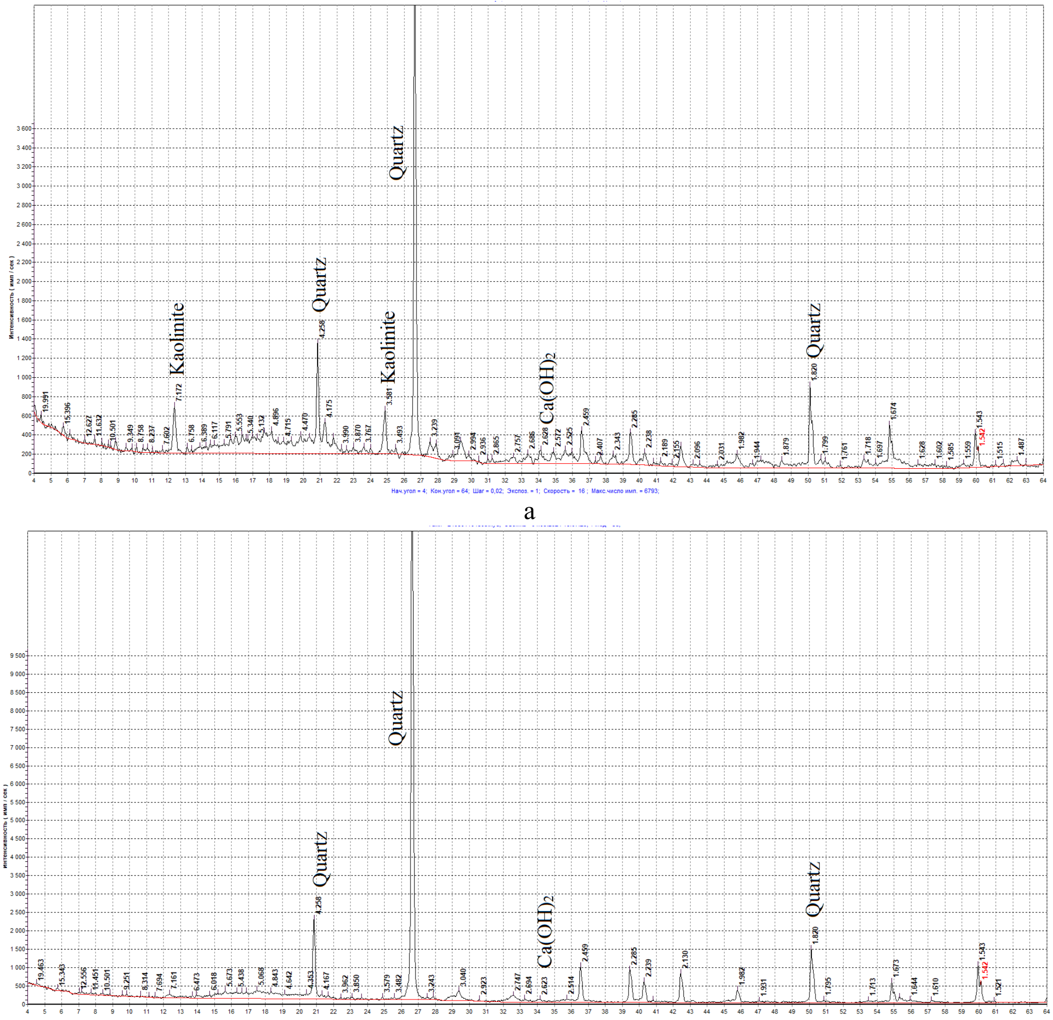


Fig. 3. Derivatogram of autoclave silicate materials with a laterite content – 40 wt.%, volcanic ash – 25 wt. %, CaO –10 %



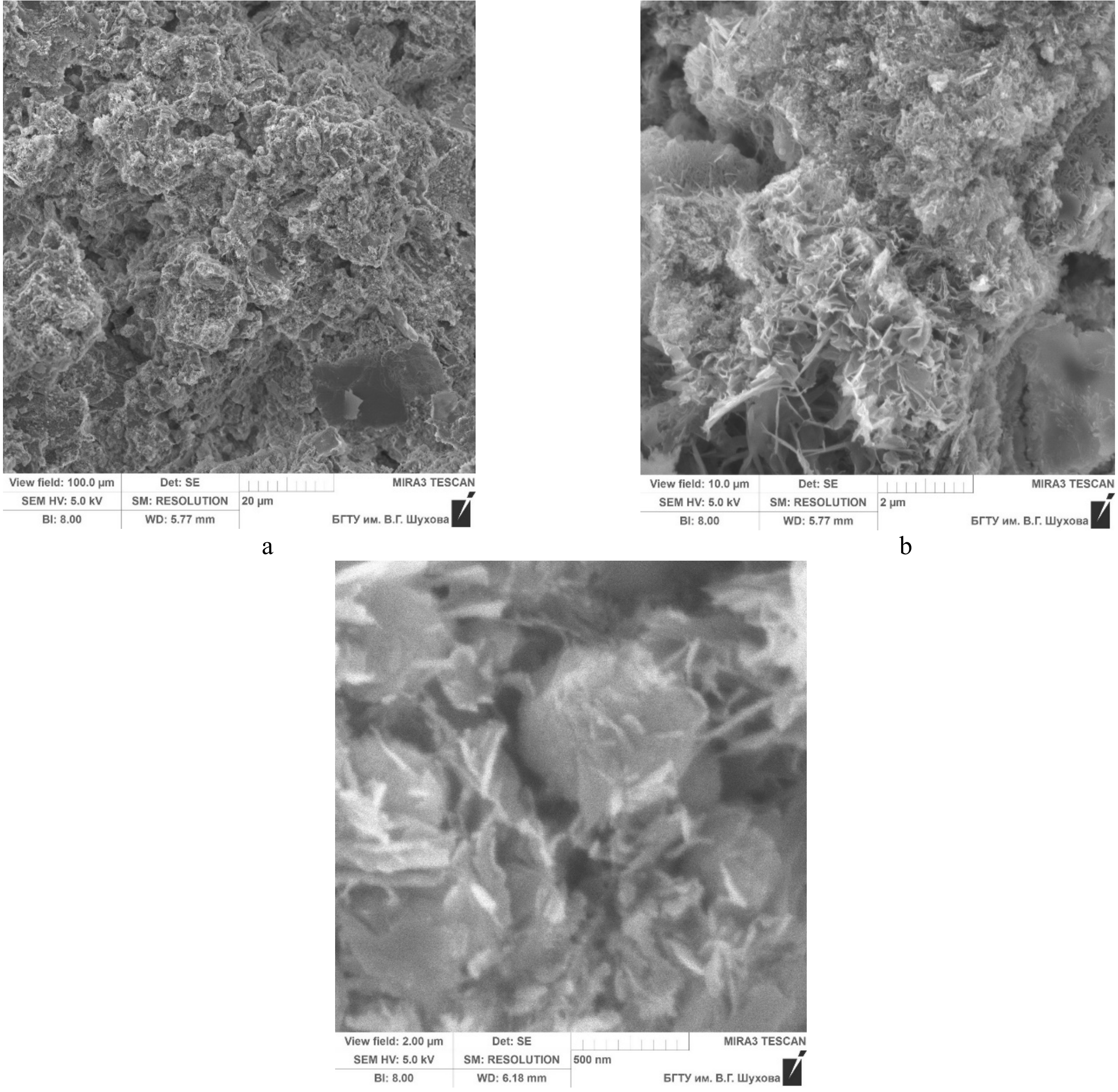
a

b

Fig. 4. Radiographs of autoclave silicate materials (a) laterite content – 40 wt.%, volcanic ash – 25 wt. %, CaO – 10 wt. %, and (b) laterite – 10 wt.%, volcanic ash –5 wt. %, CaO – 10 wt.%

The mechanical properties of the silicate composites are predominantly influenced by the phase composition and the morphological characteristics of the cementitious hydration products developed under hydrothermal conditions. The SEM analysis, in SE and BSE modes, showed high mechanical strength phases. The obtained samples exhibit the distinct feature of possessing compact aggregates ranging from 10 to 20 microns in diameter, within which the predominant binder is located, as illustrated in the electron scanning microscope images presented in Fig. 5a. This specific microstructural arrangement can be attributed to the matrix.

The cementing agent in the samples is a curved plate, intertwined and interconnected, forming a continuous spatial grid (Fig. 5b). These grids connect larger aggregates, which, obviously, are also products of interaction between the components of the raw material mixture, having a denser microstructure. The synthesized neoplasms are low-base calcium hydrosilicates, in particular tobermorite $C_5S_6H_5$. The sizes of the platinum neoplasms are 100–500 nm; the thickness is 10–20 nm (Fig. 5c). Aluminosilicate rocks are used as raw materials, therefore, the formation of aluminum-containing tobermorite is most likely.



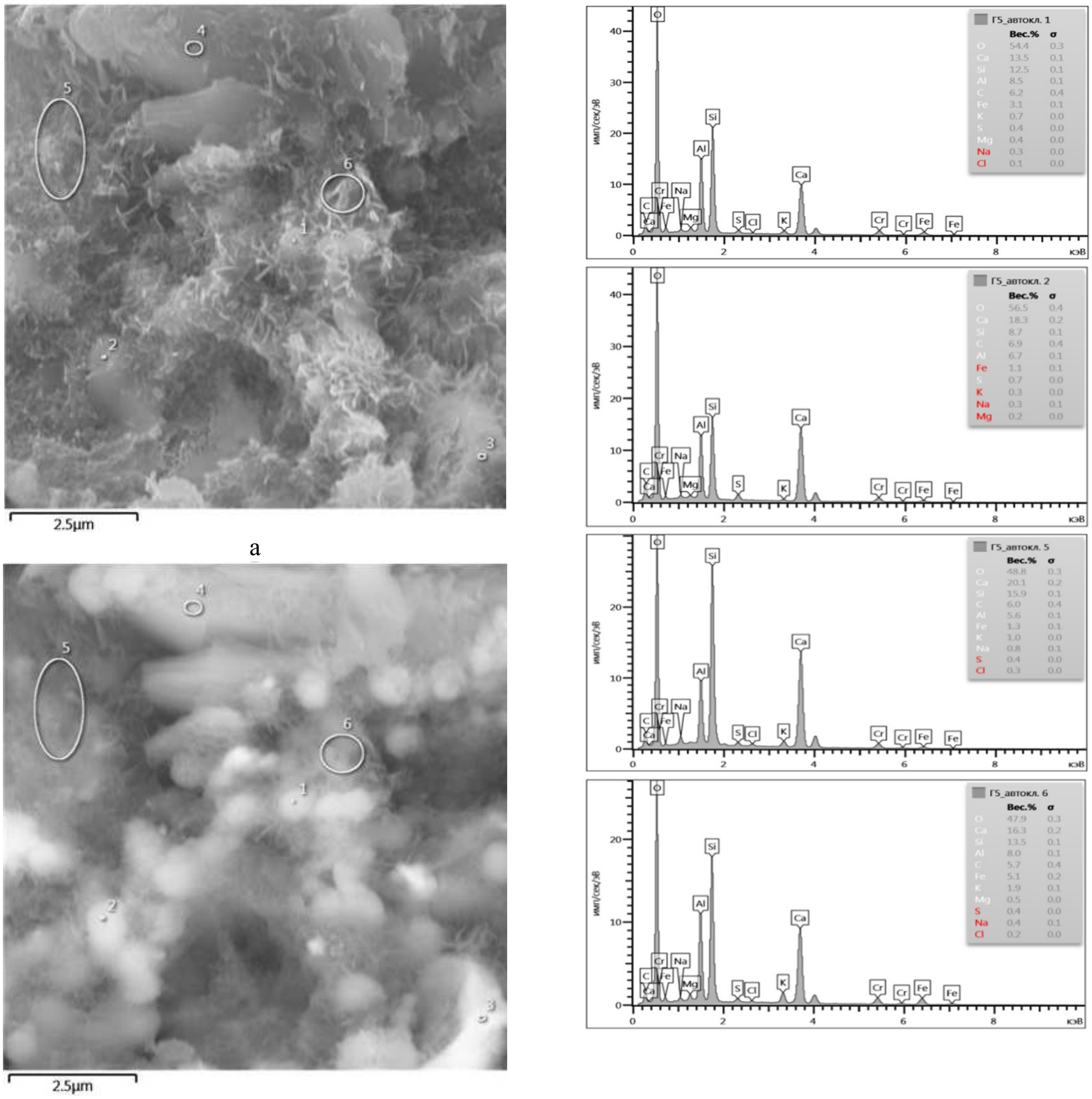
a b

c

Fig. 5. Microstructure of autoclave silicate materials with a laterite content– 40 wt.%, volcanic ash – 25 wt. %, CaO – 10 %, SEM: a – ×1000; b – ×10000; c – ×50000

In the micrograph, spherical formations (globules) up to 800 nm in size are observed in the structure of the samples, which are surrounded by a network of neoplasms (Fig. 6). These spherical formations of high density are clearly observed in the BSE mode (Fig. 6b: positions 1, 2). For the elemental analysis of samples, the energy dispersion spectroscopy (EDS) method was used. According to the results of EDS analysis, these substances (Fig. 6c) contain mainly O, Si, Al and Ca. Obviously, globules are a mixture of amorphous silicates and calcium aluminates and are intermediate compounds from which neoplasms are formed.

The region characterized by a spatial network of neoplasms (refer to Fig. 6: positions 5 and 6) additionally comprises elements such as O, Si, Al, and Ca, as indicated by the EDS data. This observation suggests the formation of aluminum-bearing tobermorite. Moreover, the formation of $C_3AS_xH_{(6-2x)}$ hydrogranates is also possible (Fig. 4a and 4b, reflexes 2.74–2.75 Å), thereby confirming the findings derived from the DTA analysis. Through calculations derived from X-ray analysis, the silica concentration present within the hydrogranates has been ascertained to lie within the interval of 1.2–1.4 mol.



a

b c

Fig. 6. Image of SEM – ×10000, a –SE, b – BSE , c – EDS spectra of autoclave silicate materials with a laterite content – 40 wt.%, volcanic ash –25 wt. % and CaO –10 %

Consequently, the combination of laterite and volcanic ash yields a significantly high reactivity of the raw material mixture during autoclave processing. The resultant interaction of the polymineral raw materials with lime facilitating the production of calcium hydrosilicates, aluminum-containing tobermorite, and hydrogranates. Simultaneously, this process engenders an optimal microstructure of the cementing agent, which in turn ensures a high physical and mechanical properties for the autoclave silicate materials.

Conclusions. In this study, mathematical planning matrix is established explaining the effect of laterite, volcanic ash and active CaO content on the physico-mechanical properties of autoclave silicate materials, which facilitates the determination of rational compositions of the raw material mixture for the production of autoclavable silicate materials. Based on the obtained results it can be concluded that:

1. It is established that that the optimal lime content (8 wt.%) results in compressive strengths of 25 MPa at 10 wt.% laterite and 25 weight percent volcanic ash, and 24 MPa at 25 wt.% laterite and 25 wt.% volcanic ash. A 19 MPa compressive strength is achieved at 6 wt.% lime, 40 wt.%t laterite, and 5 wt.% volcanic ash. The samples exhibit densities exceeding 1900 kg/m^3 and high water-resistance. The best choice depends on the necessary structural soundness as well as the cost and availability of the individual raw materials.

2. Differential thermal analysis and XRD results revealed that there is no significant unbounded Ca(OH)$_2$ and clay minerals within the analysed samples which implies the process of phase formation occurs with considerable intensity.

3. The high reactivity of the components of the raw material mixture based on laterite and volcanic ash has been established. The features of phase formation in the "CaO–SiO$_2$–Fe$_2$O$_3$–H$_2$O" system under hydrothermal conditions have been revealed. The

phase formation is accelerated with the synthesis of low-base calcium hydrosilicates CSH(B), likely aluminum-containing tobermorite and hydrogranates of the composition $C3AS_xH_{(6-2x)}$ forming an optimal microstructure of the cementing agent, which ensures high physical and mechanical properties of the autoclave silicate materials. Spherical formations (globules) which are surrounded by a network of neoplasms are observed in the structure of the samples. Gobules are a mixture of amorphous silicates and calcium aluminates and are intermediate compounds from which neoplasms are formed.

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ВЛИЯНИЕ АЛЮМОСИЛИКАТНОГО СЫРЬЯ НА ПОВЫШЕНИЕ КАЧЕСТВА АВТОКЛАВНЫХ СИЛИКАТНЫХ МАТЕРИАЛОВ

***Аннотация**. Для улучшения физико-механических свойств силикатных материалов, подвергнутых автоклавной обработке, и расширения спектра используемого сырья в данном исследовании использовались латеритные породы и вулканический пепел, добытые из месторождений на территории Государства Эритрея. С использованием метода планирования эксперимента изучено влияние латеритных пород, вулканического пепла и* $CaO_{акт}$ *на физико-механические характеристики полученных образцов. Прочность на сжатие значительно возросла с увеличением содержания вулканического пепла, достигнув значений 25 МПа для образцов, содержащих 25 мас.% вулканического пепла и 8 мас.% извести, что составляет примерно 50 %-ное увеличение по сравнению со значениями, полученными при 5 мас.% вулканического пепла.. При использовании этих композиций средняя плотность превысила 1900 кг/м*^{3}*, водопоглощение составило 8 мас. %. Силикатные материалы обладают высокой водостойкостью, коэффициент размягчения превышает 0,90. Полученные результаты также предоставляют широкий выбор составов на основе изучаемого сырья с высокими физико-механическими характеристиками, позволяющими учитывать доступность и экономическую целесообразность сырья в зависимости от требуемой структурной целостности. Синтезированные новообразования, присутствующие в образцах, классифицируются как низкоосновные гидросиликаты кальция CSH(B), в частности глиноземсодержащий тоберморит* $C_5S_6H_5$ *и гидрогранаты состава* $C_3AS_xH_{(6\text{-}2x)}$*. Следовательно, латерит и вулканический пепел обеспечивают высокую реакционную способность сырьевой смеси системы "*$CaO–SiO_2–Al_2O_3–Fe_2O_3–H_2O$*" при автоклавной обработке.*

***Ключевые слова**: латерит, известь, вулканический пепел, автоклавная обработка, физико-механические свойства.*

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