

## ANNOTATION

dissertation on the topic: "Technology and Physical-Mechanical Properties of Wall Ceramics  
Based on Siliceous Rock – Opoka of Western Kazakhstan"  
for the degree of Doctor of Philosophy (PhD)  
in the educational program 6D073000 – "Production of Construction Materials, Products, and  
Structures"

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**Research Objective.** Development of technology for producing wall ceramics based on siliceous rock – opoka of Western Kazakhstan using the semi-dry pressing method.

The idea of the dissertation research is to create a technology for producing wall ceramics based on siliceous rock - opoka of Western Kazakhstan using the semi-dry pressing method, distinguished by improved thermal protection and physical-mechanical properties that meet energy efficiency requirements.

**In accordance with the research idea, the following tasks were set:**

- Study of the material composition and ceramic properties of siliceous rock – opoka from the Taskala deposit;
- Development of compositions and study of the physical-mechanical properties in the composition of siliceous rock - opoka – montmorillonite clay;
- Investigation of the influence of firing temperature on changes in the physical-mechanical properties of samples based on the developed ceramic mass compositions;
- Study of the structural formation in the ceramic composition of siliceous rock - opoka – montmorillonite clay;
- Investigation of the effect of moisture on the molding properties of the ceramic composition;
- Study of the effect of pressing pressure on the technological and physical-mechanical properties of the raw material and heat-treated samples;
- Development of an optimal firing regime for the products;
- Pilot-industrial implementation of the semi-dry pressing technology based on the raw material composition of siliceous rock - opoka – montmorillonite clay at the operating plant JSC "West Kazakhstan Corporation of Building Materials" (ZKKSM);
- Determination of the technical and economic efficiency of the proposed technology for producing wall ceramics based on siliceous rock – opoka.

**Research Object.** Siliceous rock – opoka of the Western Kazakhstan deposit.

**Research Scope.** Comprehensive and rational use of natural and man-made resources. Deep processing of raw materials and products.

The dissertation aligns with the Concept for the Development of Housing and Communal Infrastructure until 2026, approved by the Resolution of the Government of the Republic of Kazakhstan (No. 736 dated 23.09.2022), as well as with the priority areas of scientific development for 2023–2025, approved by the Higher Scientific and Technical Commission, particularly in the field of “Geology, extraction and processing of mineral and hydrocarbon raw materials, new materials, technologies, safe products and structures.”

The dissertation was carried out within the framework of the grant funding project of the Science Committee of the Ministry of Science and Higher Education of the Republic of

Kazakhstan under the topic AR08855772 “Technology for porous thermal insulation ceramics based on siliceous rocks–opoka of Western Kazakhstan.”

**Methods for Achieving the Set Tasks.** Literature and patent analysis focused on studying ceramic masses using various clay materials; Determination of the chemical-mineralogical composition of the studied samples, investigation of the microstructure of heat-treated ceramic samples in scientific laboratories of the Republic of Kazakhstan; Conducting comprehensive tests of ceramic masses in accordance with generally accepted scientific research methodologies, including analytical, laboratory, technological developments, and pilot-industrial tests; Conducting tests under production conditions and calculating economic efficiency.

#### **Scientific Novelty of the Dissertation:**

- Technological solutions have been developed for producing effective wall ceramic products based on siliceous rock - opoka, distinguished by improved thermal protection and operational properties;
- The main provisions of the technology for producing wall ceramics from opoka raw materials using the semi-dry pressing method have been formulated. It has been established that to obtain quality products with the required physical-mechanical characteristics, pressing should be performed within the range of 15-20 MPa at a press powder moisture content of 12-15%;
- It has been determined that the firing temperature for products based on opoka, ensuring low density and thermal conductivity while maintaining the required strength indicators, is in the temperature range of 950–1100 °C. The resulting products have a reduced density (1100-1250 kg/m<sup>3</sup>) and low thermal conductivity (0.2-0.4 W/m·°C), which classifies them as energy-efficient;
- New qualitative patterns of phase composition and structure formation of fired products based on opoka have been established. It has been determined that opal transforms into cristobalite during firing. As the firing temperature increases, the structural perfection of cristobalite improves. The presence of low-melting clay impurities activates this process.

#### **Scientific Results Submitted for Defense:**

- Results of the study of the material composition and ceramic properties of siliceous rock – opoka from the Taskala deposit;
- Results of the research on the development of compositions and the study of the physical-mechanical properties in the composition of siliceous rock - opoka – montmorillonite clay;
- Results of the study on the influence of firing temperature on changes in the physical-mechanical properties of samples based on the developed ceramic mass compositions;
- Results of the study on the structural formation in the ceramic composition of siliceous rock - opoka – montmorillonite clay;
- Results of the study on the influence of moisture on the molding properties of the ceramic composition;
- Results of the study on the influence of pressing pressure on the technological and physical-mechanical properties of the raw material and heat-treated samples;
- Development of an optimal firing regime for the products;
- Results of the pilot-industrial implementation of the semi-dry pressing technology based on the raw material composition of siliceous rock - opoka – montmorillonite clay;
- Results of the technical and economic efficiency of the proposed technology for producing wall ceramics based on siliceous rock – opoka.

**Practical relevance of the work.** The implementation of the proposed technology for producing wall ceramics allows for an increase in the range of effective domestic building materials. Wall ceramics based on opoka have low density, which, for solid bricks, ranges from

1100 to 1250 kg/m<sup>3</sup>. Considering porosity, this allows for the production of conditionally effective and highly efficient products with an average density class from 0.8 to 1.4. The resulting wall materials are characterized by an increased constructive quality coefficient.

**Experience in Implementing Research Results into Production.** The developed new compositions and technological solutions for producing wall ceramics based on opoka using the semi-dry pressing method were tested at the JSC "West Kazakhstan Corporation of Building Materials" (ZKKSM) plant.

**Scientific and Practical Significance of the Dissertation Research Results** is confirmed by the act of implementing the research results into the educational process of the West Kazakhstan Agrarian and Technical University named after Zhangir Khan and the Kazakhstan University of Innovation and Telecommunication Systems, as well as by acts of implementation in production.

**Validity and Reliability of Scientific Provisions, Conclusions, and Recommendations.** Laboratory studies were conducted in laboratories equipped with modern equipment. The results of laboratory studies of ceramic masses are substantiated in accordance with conclusions and recommendations and confirmed by pilot-industrial tests. The physical-mechanical characteristics of the final products comply with regulatory documents, and the reliability of laboratory research results is confirmed by pilot-industrial tests at operating plants.

**Personal Contribution of the Author to Science Includes:** Development of new compositions of ceramic masses and rational technological solutions for producing wall ceramics using the semi-dry pressing method; Establishing the main patterns of changes in the physical-mechanical properties of wall ceramics depending on moisture content, pressing pressure, firing temperature, and phase-mineral formation processes within a temperature range of up to 1100 °C in the raw material system siliceous rock – opoka – montmorillonite clay.

The developed new compositions and technological solutions for producing wall ceramics based on opoka using the semi-dry pressing method were tested at the JSC "West Kazakhstan Corporation of Building Materials" (ZKKSM) plant. A pilot batch of 10,000 wall ceramic units was produced.

The work was carried out in the "Building Materials and Technologies" research laboratory at Zhangir Khan West Kazakhstan Agrarian-Technical University.

During the analysis of the chemical composition of tripoli and montmorillonite clay, modeling of the granulometric composition of raw materials, and forecasting of the physical and mechanical properties of the samples, MATLAB and FlexSet programs were used.

To select the optimal composition of ceramic masses, mathematical models were applied using the Statistica and SPSS software packages.

**Approval of the Work.** The research results were presented and discussed in the following scientific publications and international scientific-practical conferences:

- Montayev S., Montayeva N., Taudaeva A.A., Ryskaliyev M., Zharylgapov S. Investigation of the Compositional Raw Mixtures for Preparation of the Sintered Microporous Material and Mineral Feed Additives // Evergreen. VOL 10(3), pp. 1296–1306, 2023. [Scopus percentile by Cite Score: 52.] <https://www.scopus.com/record/display.uri?eid=2-s2.0-85173898665&origin=resultslist>

- Montayev S.A., Narikov K.A., Shakeshev B.T., Taudaeva A.A., Dosov K.Zh. Influence of a powder-forming additive on the physical-mechanical properties and structure of a

ceramic material // Functional Composites and Structures. VOL 5(31), DOI 10.1088/2631-6331/acf11. [Scopus percentile by Cite Score: 67.]  
<https://www.scopus.com/record/display.uri?eid=2-s2.0-85170273918&origin=resultslist>

- Montayeva N.S., Montayev S.A., Taudaeva A.A., Ryskaliev M.Zh., Zharylgapov S.M. The use of therapeutic and heat-insulating properties of siliceous gaize in the agricultural sector of the Republic of Kazakhstan // Periodicals of Engineering and Natural Sciences. Vol 9(4), pp. 81–97, 2021. [Scopus percentile by Cite Score: 76.]  
<https://www.scopus.com/record/display.uri?eid=2s2.085117167292&origin=resultslist>

- Montayev S.A., Dosov K.Zh., Adilova N.B., Taudaeva A.A. Investigation of raw material compositions for obtaining ceramic aggregate and porous thermal insulation structural wall ceramics // Penza State University of Architecture and Construction. Regional Architecture and Construction, 4(49), Penza, 2021. - pp. 54–62.

- Montayev S.A., Taudaeva A.A., Zharylgapov S.M. The effect of firing temperature on changes in the physical-mechanical properties of wall ceramics based on siliceous rock – opoka // Penza State University of Architecture and Construction. Regional Architecture and Construction, 4(49), Penza, 2021. - pp. 63–70.

- Montayev S.A., Shakeshev B.T., Taudaeva A.A., Ryskaliev M.Zh., Zharylgapov S.M. The role of corrective additives in obtaining high-efficiency wall ceramics based on siliceous rock – opoka // Bulletin of the Kazakh Leading Academy of Architecture and Construction, No. 2 (84), Almaty, 2022. - pp. 261–268.

- Montayev S.A., Taudaeva A.A., Montayeva N.S., Ryskaliev M.Zh. Development of raw material compositions based on clay deposits of Western Kazakhstan for obtaining efficient ceramic materials // Science News of Kazakhstan, No. 4 (147), Almaty, 2020. - pp. 133–145.

### **Publication of Research Results.**

The main provisions and results of the dissertation work are presented in seven scientific papers, including three publications in journals indexed in the Scopus database and four publications in editions recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan. Structure and Volume of the Dissertation.

**The dissertation work**, in accordance with the content and research objectives, consists of an introduction, five chapters, a conclusion, a reference list of 143 sources, and appendices. The total volume of the work is 114 pages of computer-typed text, including 45 figures and 14 tables.