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CONTENTS

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THERMAL AND CHEMICAL PROPERTIES OF LIMESTONE FROM THE "UCH O'JAQ" DEPOSIT

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Annotatsiya. Ushbu maqolada "Uch o'jaq" koni ohaktoshining termik va kimyoviy xususiyatlari o'rganilgan. Tadqiqot jarayonida namunalar termografik, rentgenfazaviy va kimyoviy usullar yordamida tahlil qilindi. Olingan natijalar shuni ko'rsatdiki, mazkur kon ohaktoshi kalsitga boy bo'lib, portlandsement klinkeri ishlab chiqarish uchun muhim bo'lgan dolomit, kvarts va temir oksidlari kabi komponentlarni ham o'z ichiga oladi. Termografik tahlil ohaktoshning qizdirilgandagi reaksiyasini hamda kalsitning kristall panjarasining buzilish xususiyatlarini qayd etdi. Olingan ma'lumotlarga asoslanib, "Uch o'jaq" koni ohaktoshi portlandsement ishlab chiqarishda karbonat komponent sifatida muhim mineral xomashyo ekanligi aniqlandi.

Kalit so'zlar: *"Uch o'jaq" koni, ohaktosh, termografik tahlil, kimyoviy tarkib, rentgenfazaviy tahlil, kalsit, portlandsement, klinker, mineralogik tahlil, xomashyo.*

Аннотация. В данной статье изучены термические и химические свойства известняка месторождения "Uch o'jaq". В ходе исследования образцы были проанализированы с использованием термографического, рентгенофазового и химического методов. Полученные результаты показали, что известняк данного месторождения богат кальцитом, а также содержит такие важные для производства портландцементного клинкера компоненты, как доломит, кварц и оксиды железа. Термографический анализ зафиксировал реакцию известняка на нагревание и особенности разрушения кристаллической решётки кальцита. На основе полученных данных установлено, что известняк месторождения "Uch o'jaq" является важным минеральным сырьём в качестве карбонатного компонента при производстве портландцемента.

Ключевые слова: *месторождение "Uch o'jaq", известняк, термографический анализ, химический состав, рентгенофазовый анализ, кальцит, портландцемент, клинкер, минералогический анализ, сырьё.*

Abstract. This article examines the thermal and chemical properties of limestone from the "Uch o'jaq" deposit. During the study, the samples were analyzed using thermographic, X-ray phase, and chemical methods. The results showed that the limestone from this deposit is rich in calcite and also contains components important for the production of Portland cement clinker, such as dolomite, quartz, and iron oxides. Thermographic analysis recorded the limestone's response to heating and the characteristics of the calcite crystal lattice decomposition. Based on the obtained data, it was established that the limestone from the "Uch o'jaq" deposit is an important mineral raw material as a carbonate component in the production of Portland cement.

Keywords: *"Uch o'jaq" deposit, limestone, thermographic analysis, chemical composition, X-ray phase analysis, calcite, Portland cement, clinker, mineralogical analysis, raw material.*

Introduction

In contemporary building materials production, the quality of raw materials and the efficient use of natural resources are of crucial importance. As the principal component in Portland cement production, limestone requires a thorough investigation of its mineralogical and chemical properties.

The "Uch o'jaq" deposit, located in the Khorezm region of Uzbekistan within the Kyzylkum–Lower Amu Darya carbonate zone, is geologically represented by limestone ($CaCO_3$), marl, sandstone, and local gypsum interlayers. Its high calcium oxide (CaO) content and low levels of impurities (dolomite, quartz, iron oxides) make this deposit an industrially valuable raw material for cement manufacturing [1-9].

Thermal, physical, and X-ray analyses of samples revealed high thermal resistance, structural stability, and distinctive crystal lattice features. Thermographic studies also identified the reactions of organic impurities and iron oxides upon heating, indicating potential for enhanced energy efficiency and quality stability in Portland clinker production.

Consequently, the "Uch o'jaq" deposit holds strategic significance for Uzbekistan's cement industry, combining favorable chemical composition, advantageous technological properties, and substantial reserves.

Research Methodology

The study was aimed at determining the physicochemical properties of limestone samples extracted from the Uch o'jaq deposit and assessing their suitability as raw material for the cement industry. Two types of limestone were selected for investigation—light yellow and brownish varieties, belonging to the group of soft limestones common in the Lower Amu Darya region. Their macrostructure, porosity, and surface morphology were analyzed through visual assessment.

The thermal properties of the samples were studied using differential thermal analysis (DTA) with heating up to 1100 °C. The thermogram revealed four stages of thermal transformations: the first stage (95 °C) corresponded to the removal of hygroscopic moisture; the second and third (160 °C and 270 °C) indicated exothermic reactions associated with the combustion of organic impurities and oxidation of divalent iron; the fourth stage (686–808 °C) was characterized by an endothermic process caused by the decomposition of the calcite crystal lattice and the release of carbon dioxide. These results provide insights into the thermal stability of the samples and the proportion of the carbonate phase in their composition [2].

The mineralogical composition was determined by X-ray diffraction (XRD). The results showed that calcite is the predominant mineral in the limestone. In addition, impurities such as quartz (silicon dioxide), kaolinite, and iron- and sulfur-bearing minerals-pyrite, glauconite, and goethite-were identified. The presence of these components affects the physicochemical reactivity of limestone, as well as its stability and oxidation potential during cement clinker burning [4].

Chemical analysis identified the content of the main oxide components: SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, SO_3, and other trace elements. Special attention is given to the second sample, which showed an increased iron oxide content (1.89%), of practical importance for Portland clinker production, as it allows a reduction in the amount of iron-containing corrective additives [5]. The high concentration of CaO and optimal loss on ignition (LOI) values further confirm the feasibility of using limestone from this deposit as a carbonate raw material for the cement industry [2, 3].

Analysis and Results

The "Uch o'jaq" limestone deposit, located in the Lower Amu Darya region, belongs to the group of rare soft limestones. This deposit possesses sufficient industrial reserves and, in terms of geographical position, is considered convenient for extraction. For cement production, raw materials rich in the mineral calcite are required; however, even limestones regarded as very pure contain certain impurities of dolomite, quartz, and iron oxides (2–3%) [8].

Visual examination of the limestone samples collected from the "Uch o'jaq" deposit revealed their division into two types based on color. Figures 1 and 2 show the appearance of the yellowish-white and brownish limestone extracted from this deposit. The macrostructure of the samples is characterized by a granular texture and irregular fracture lines. In some cases, pores ranging in size from 1 to 5 mm were observed on the fracture surfaces.

Figure 1. Light-yellow sample obtained from the "*Uch o'jaq"* limestone deposit.

Figure 2. Brownish sample obtained from the "*Uch o'jaq"* limestone deposit.

On the thermogram of limestone from the "*Uch o'jaq"* deposit heated up to 1100 °C, four stages can be observed (Figure 3). The first stage is weakly expressed and appears as an endothermic effect at 95 °C, indicating the loss of hygroscopic moisture [4]. The second and third stages are accompanied by exothermic effects in the intervals of 140–180 °C and 250–290 °C, with maxima at 160 °C and 270 °C, respectively. These effects may be associated with the combustion of organic impurities and the oxidation of divalent iron. The fourth stage occurs within the range of 686.4–808.2 °C (maximum at 785.5 °C) with heat absorption, which corresponds to the decomposition of the calcite crystal lattice and the release of carbon dioxide [2].

X-ray diffraction (XRD) analysis of limestone from the "*Uch o'jaq*" deposit allowed a detailed determination of its mineralogical composition (Figure 4). The main component of the rock is calcite ($CaCO_3$), identified by a number of characteristic interplanar spacings: d = 0.383, 0.333, 0.302, 0.248, 0.227, 0.209, 0.187, 0.160, 0.152, and 0.142 nm. The predominance of calcite indicates the high purity of the limestone and its suitability as a primary carbonate component for Portland cement clinker production [6].

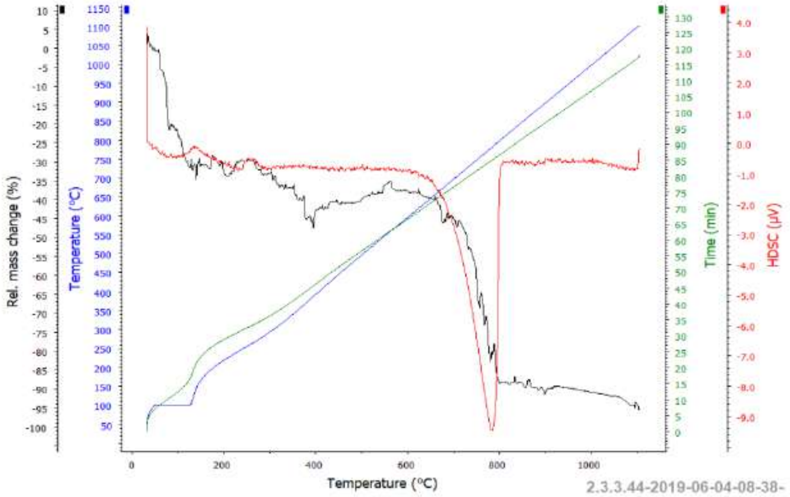

Figure 3. Thermogram of limestone from the "Uch o'jaq" deposit.

In addition to calcite, the samples revealed the presence of quartz (d = 0.333, 0.228, 0.152, 0.141 nm), which, despite its relative chemical inertness during firing, may play a role in the thermal stabilization of the raw mixture. Kaolinite was also identified—a clay mineral with interplanar spacings of 0.144 and 0.142 nm. Its presence indicates secondary aluminosilicates, which can influence the physicochemical properties of the mixture during raw meal formation.

Among the impurities, pyrite (d = 0.191 nm), glauconite (d = 0.333, 0.144 nm), and goethite (d = 0.192 nm) were detected. These minerals contain iron and can contribute additionally to the phase composition of cement clinker. The presence of pyrite is particularly significant, as it can serve as a natural source of iron oxides, reducing the need for external iron-containing additives. Thus, the mineral composition of limestone from the "*Uch o'jaq*" deposit represents a balanced combination of the main carbonate component and beneficial impurities, ensuring its high technological value for the cement industry.

The chemical composition of the "*Uch o'jaq*" limestone is presented in Table 1. According to the obtained data, the samples contain the main oxides typical of carbonate rocks, including CaO, SiO_2, Al_2O_3, Fe_2O_3, and MgO. Of particular note is the second sample, which showed a relatively high content of iron oxide (Fe_2O_3), reaching 1.89%. This feature makes the material especially valuable in the context of Portland cement clinker production [2, 3].

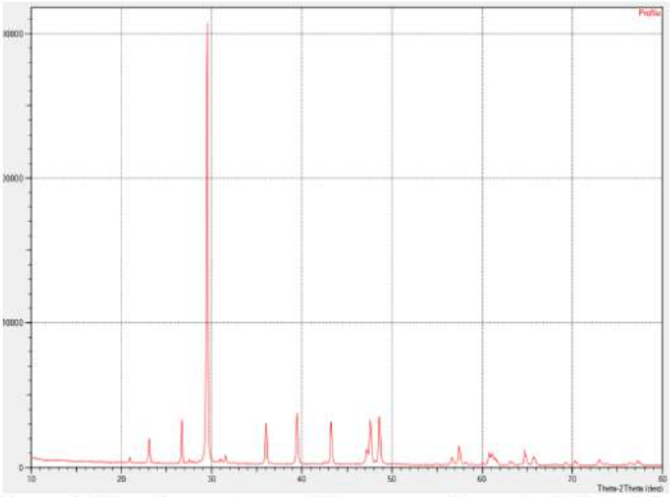

Figure 4. X-ray diffraction pattern of limestone from the "Uch o'jaq" deposit.

In the preparation of raw meals for cement burning, it is important to ensure the presence of sufficient iron-bearing components, as they promote the formation of ferrite phases and improve the physico-mechanical properties of cement. Typically, additional additives such as iron ore or metallurgical slags are introduced into the raw mix for this purpose. However, the use of limestone with an already elevated Fe_2O_3 content allows for the partial or complete elimination of external iron sources, which not only simplifies the technological process but also reduces the production cost of the final product.

Thus, limestone containing an increased amount of iron oxide represents not only a high-quality carbonate raw material but also an effective carrier of iron, enabling the optimization of the raw mix composition and enhancing the economic efficiency of Portland cement production. This makes the second sample particularly promising for industrial application, especially under conditions where a balance between quality, cost, and process efficiency is required [1].

Table 1. Chemical composition of limestone from the Uch o'jaq deposit.

№	Chemical composition, %									
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	TiO_2	Na_2O	K_2O	LOI
1	4,91	0,89	0,96	51,93	0,67	0,75	0,42	0,41	0,20	38,84
2	7,66	1,17	1,89	50,19	0,64	0,44	0,47	0,52	0,29	36,73

Conclusions

The results of the study demonstrate that limestone from the *"Uch o'jaq"* deposit, owing to its chemical, mineralogical, and thermal properties, has high potential for use as a primary raw material in Portland cement production. The high calcium oxide (CaO) content, the presence of carbonates, and the mineral composition—particularly calcite, dolomite, quartz, and iron oxides—make this limestone a suitable material for inclusion in cement clinker. The particular importance is the second sample, in which the Fe_2O_3 content reaches 1.89%. This makes the limestone a potential substitute for iron-bearing additives [5]. As a result, the need for additional metallurgical by-products is reduced, thereby increasing the economic efficiency of production. Furthermore, the granular structure of the limestone, together with the presence of macroscopic fractures and porosity, ensures stability during thermal processing. The thermal changes revealed in the thermogram indicate the temperature ranges of carbonate decomposition, which serve as a basis for determining optimal firing regimes.

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