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RESEARCH OF HARDNESS FOR ANCIENT CERAMICS OF KYRGYZSTAN

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Ceramic production played an important role in the early stages of the formation and development of industry. In Central Asia, including Kyrgyzstan, its important role preserved for the whole time. The technical level and conditions of production organization, technical potential are the main moments in determining its characteristics. Therefore, the disclosure of the mechanism and conditions for changing the technique and technology of ceramic production in historical development is an important factor. The nature of the study of ceramic production in its historical development requires the identification of a variety of conditions and facts of the technical process, involving the use of different methods of research.

One of the main methods for studying ceramics is the investigation of hardness, because it underlies the strength and durability of clay products. In connection with the foregoing, the purpose of this paper is studying the hardness of ancient ceramics which found on the territory of Kyrgyzstan and conducting a comparative analysis with modern ceramics.

Keywords: ancient ceramics, hardness, strength, the firing temperature of ceramics.

ИССЛЕДОВАНИЕ ТВЕРДОСТИ ДРЕВНЕЙ КЕРАМИКИ КЫРГЫЗСТАНА

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Керамическое производство играло важную роль на первых этапах становления и развития промышленности. В Средней Азии, в том числе и Кыргызстане, на протяжении всего времени сохранялась его важная роль. Технический уровень и условия организации производства, технический потенциал выступают основными моментами в определении его характеристики. Поэтому раскрытие механизма и условий изменения техники и технологии керамического производства в историческом развитии является важным фактором. Характер исследования керамического производства в его историческом развитии требует выявления самых разных условий и фактов технического процесса, предполагающих использование разных методов исследования.

Одним из основных методов исследования керамики является исследование твердости, поскольку она лежит в основе прочности и долговечности глиняных изделий. В связи с вышеизложенным целью настоящей статьи является исследование твердости древней керамики, обнаруженной на территории Кыргызстана, и проведение сравнительного анализа с современной керамикой.

Ключевые слова: древняя керамика, твердость, температура обжига керамики.

The study of ceramics from the territory of Kyrgyzstan is reflected in many of the archaeological works and reports, describing ceramic craft of a particular region of a certain period. A.N. Bernshtam gave a classification of methods for the ornamentation of Sogdian and Karluk periods [1], K.I. Tashbayeva studied ceramics of Tien-Shan and Altai [7], Y. Zadneprovsky described ceramics Fergana [9]. V.D. Goryacheva [2] and D.F. Vinnik [8] describe the history of the study of medieval settlements and cities of Uzgen. As the analysis of the literature, in the works of the above authors is paid little attention to the scientific and technical research. In this regard, it is necessary to study the physicochemical and physicomechanical properties of the ancient ceramics, because ceramics is the most massive and dating material [4].

The term "ceramic" refers to pottery formed of wet clay and fired to harden. In ancient times firing of clay vessels was carried out at the temperature not lower than 600^0C, and gradually increased firing temperature [7]. Modern ceramics are fired at a temperature not lower than 950^0S, and local ceramics – not less 1050^0S [3]. Temperature of firing gives strength to ceramics. Therefore, the main indicator of quality for ceramics is its hardness, because it is the basis of the strength and durability of ceramics. The purpose of this work is measure of the hardness of ancient ceramics found on the territory of Kyrgyzstan and modern ceramics, and conduction their comparative analysis.

Ceramics are soft material, so hardness measurements should be carried out at a lower load, i.e. it is necessary to determine the microhardness of the ceramic. In this connection, it was studied the microhardness of ceramic samples found in Kochkorsky and Chui districts, which were provided by the archaeologist Tabaldiev K.Sh. For comparison, measurements were made of fragments of modern ceramics made in the studio of the Art College named after S.A. Chuikov. The research was carried out in the Solid State Physics Laboratory of the Kyrgyz-Russian Slavic University named after B. Yeltsin.

Determination of microhardness was performed in the PMT-3 device that is a microscope destined to measure microhardness of metals, ceramics, minerals, and other materials.

The principle of the device's work is based on the indentation of a diamond pyramid into the test material under a specified load and measuring the linear value of the diagonal of obtained imprint. The hardness number H is defined as the quotient of the load P (in H) at lateral surface S (in meters) of the imprint on the assumption that angles of the imprint correspond to the angles of the pyramid [5]:

$$H = \frac{P}{S}\ (Pa), \qquad (1)$$

where H – hardness number in Pa;

P – load in N;

S – diagonal of imprint in meters.

Microhardness was determined on polished sections of ceramic samples at a load of 200 gram (2H), loading time 1 min.

Obtained values of microhardness are given in Table 1.

Table 1

The microhardness of ceramic samples

Location	Chap		Ak-Beshim		Balasagyn		Modern ceramics	
Period	II-I millennium BC		VIII-IX century		X-XII century			
№ sample	1	2	1	2	1	2	1	2
Microhardness, H	270 MPa	143 MPa	131 MPa	318 MPa	215 MPa	407 MPa	651 MPa	835 MPa
Average microhardness	206,5 MPa		224,4 MPa		311 MPa		743 MPa	

Results of measurement of the microhardness showed that in the average the microhardness increased over time. Comparing microhardness and the average firing temperature setting E.V. Saiko on the basis of a comprehensive method for studying the pottery for different times (Table 2) [6], that is increased for all epochs gradually, but constantly (Fig. 1), as well as microhardness (Fig. 2). Therefore, the hardness increases with increasing firing temperature.

Table 2

Average firing temperature by E.V. Saiko

Period	VI-V millennium BC	II-I millennium BC	I-II centuries	VIII-IX centuries	X-XII centuries	Modern ceramics
Firing temperature, ^{0}S	650	700	800	900	1000	1050

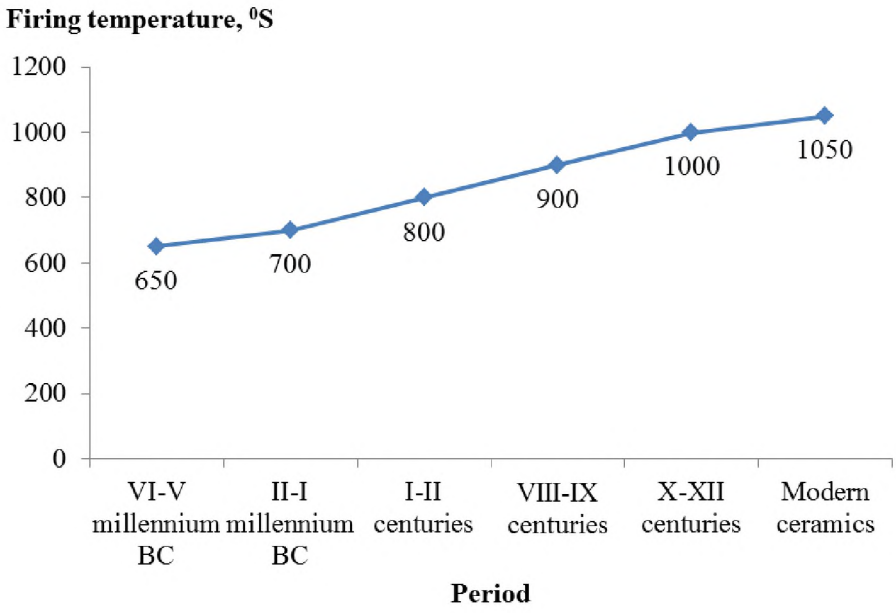

Fig. 1. Graph of depending on firing temperature of ancient and modern ceramics from the time

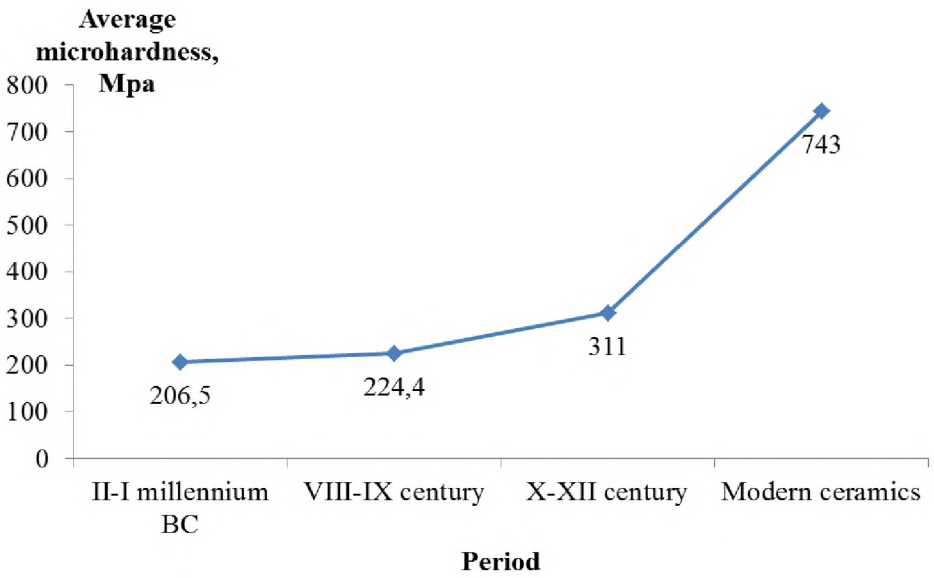

Fig. 2. Graph of depending on the microhardness of ancient and modern ceramics from the time

Conclusions: Measurement of microhardness of ceramics of different periods and modern shows that the hardness increases over time and differs sharply. Such a difference is due to the following factors:

1. The phase transition has occurred, as all transient processes in the ceramic occur at a temperature above 950^0C. At a temperature above 950^0C acicular mullet is formed which is a reinforcing system. Thereby a liquid phase is formed that connects the particles together, thereby increasing the hardness of the ceramic.

2. Ancient Ceramists cannot reach high temperatures, and also constant temperature in the furnace which leads to lowering the hardness of ceramics.

3. The composition of the clay was determined by eye, empirically, based on the experience of ceramists.

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