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## **Historical background of wood-fired ceramics firing in cross-flow kilns**

***Abstract.** This work is a comprehensive study that covers the historical, technical and creative aspects of the unique process of wood firing of ceramics. The conducted research allowed to understand the essence of wood firing, its aesthetic and cultural value more deeply. Analysis of the historical development of wood firing revealed its deep roots in the cultural traditions of different peoples. This technique, which originated thousands of years ago, remains relevant due to its ability to create unique textures, effects and emphasize the natural beauty of the material. The historical aspect shows how wood firing has transformed from a utilitarian process into an important artistic tool. A key feature of wood firing is the use of special kilns designed to maintain high temperatures for a long time. Research into different types of cross-flow wood kilns revealed their technical features and impact on the final result. It has been established that the firing process depends on many factors, including the type of wood, the atmosphere of the kiln, the temperature and the duration of firing. These parameters form the unique character of each product. The use of wood firing for artistic purposes allows to achieve unique visual effects, such as natural ash pouring, textured surfaces, natural color transitions. Wood firing is a unique process that*



*combines tradition and innovation, technology and art. Its significance lies in the ability to create objects that are not only visually striking, but also carry a deep emotional content. This technique requires skill, patience and understanding of the material, as well as the willingness to work with the element of fire, which becomes a full-fledged co-author. The research conducted not only deepened knowledge about wood firing, but also showed its limitless possibilities for creative expression. The study demonstrates that this technique remains relevant and inspiring for contemporary artists, offering endless opportunities for discovery in the field of artistic ceramics. The technology of wood firing in cross-flow kilns continues to develop, and its capabilities open up new horizons for contemporary ceramic art. Wood firing is not only a technology, but also a philosophy. It reflects the interaction of man with nature and fire, allowing the creation of unique ceramic products that cannot be repeated. This is precisely its value and unfading relevance in the world of ceramic art.*

**Keywords:** *art history; cultural history; history of ceramics; clay; artistic ceramics; kilns for wood-fired ceramics*

### **Introduction.**

Studying the history of the development of ceramics is of great importance, as it allows to better understand the past of mankind. Ceramics are not just clay and fire, but a true reflection of the culture, way of life, technologies and even beliefs of different peoples. Ceramic products are often the only thing left of ancient civilizations, and they help scientists recreate the picture of life in those distant times.

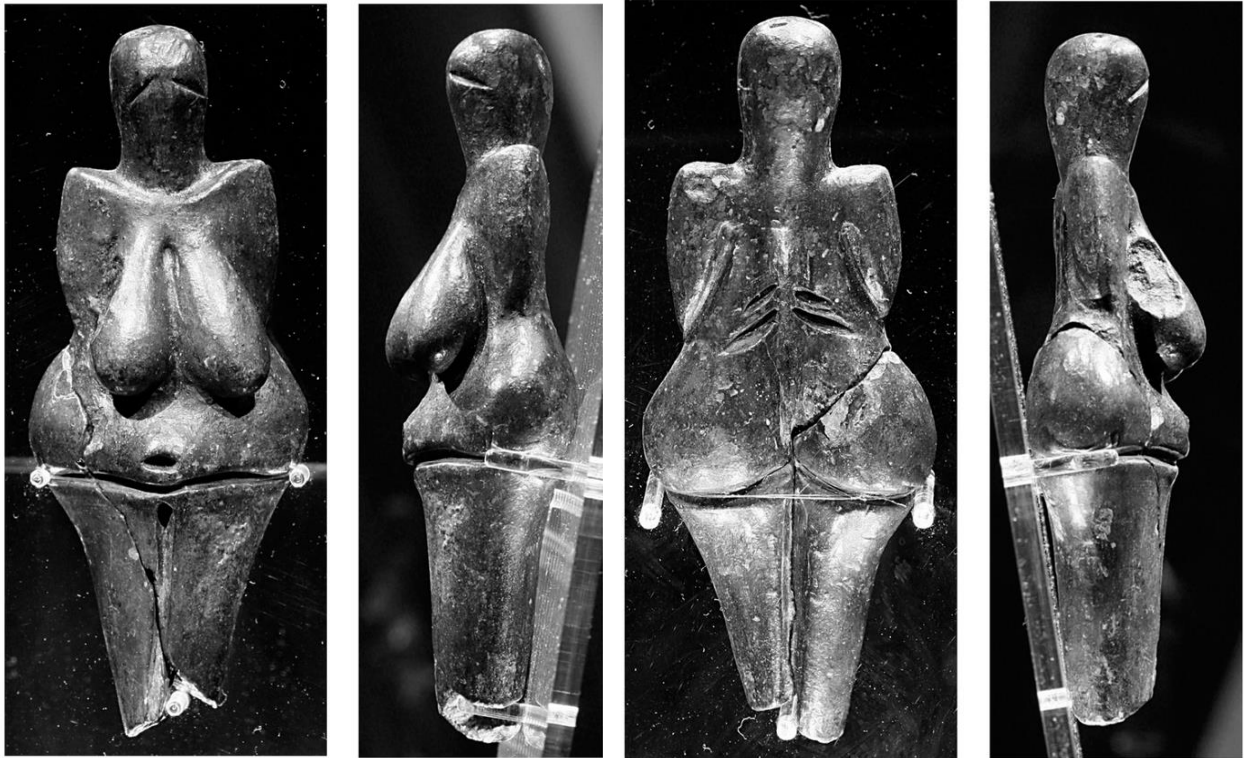
Ceramics are well preserved in the ground, so they play a key role in the work of archaeologists. By its appearance, shape or ornamentation, it is possible to determine when and where it was made, as well as find out who certain peoples traded with or what cultural influences acted on them.

In addition, the history of ceramics shows how technologies developed. Kilns, temperatures, clay composition changed, glazes appeared, new methods of decoration. All this became the basis for many modern materials that we use today not only in everyday life, but also in medicine or even in military affairs (Ałykow, Bednarz, Piechówka-Mielnik, Napiórkowska-Ałykow, & Krupa, 2022; Morito, 2022).

For artists and craftsmen, ceramics are also a source of inspiration. Ancient techniques – for example, wood firing or applying ash glaze – are actively used in author's works today, as they give unique effects that cannot be achieved in any other way.

Finally, studying ceramic heritage is a way to preserve traditions. Many craft techniques are passed down from generation to generation, and thanks to research, they can not only be preserved, but also popularized throughout the world. Some of them are even recognized as part of the intangible cultural heritage of humanity. So, by studying ceramics, we are not just exploring the past – we are learning more about ourselves, our roots, and the development of civilization as a whole.

Ceramics is one of the oldest branches of human activity, dating back thousands of years. The oldest known ceramic artifact dates back to approximately 29,000 to 22,000 years BP, during the Upper Paleolithic. It is a figurine of a woman known as the Venus from Dolni Vestonice, (Figure 1), from a small prehistoric settlement near Brno in the Czech Republic (Potvin, 2024).



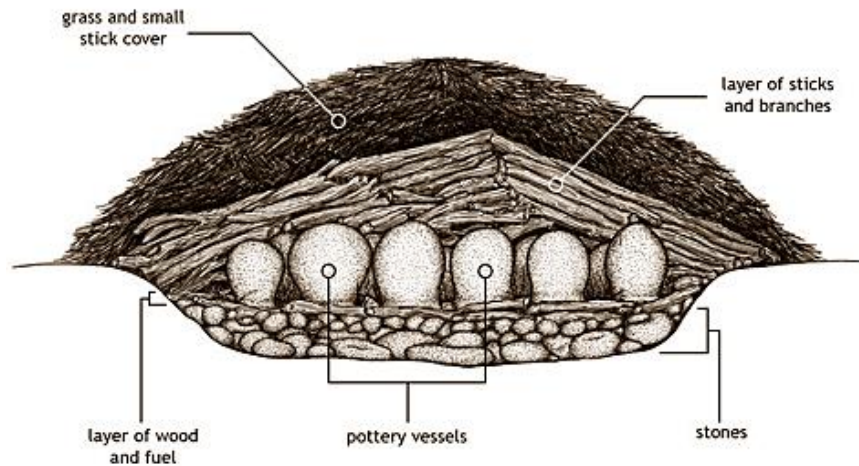
**Figure 1.** Venus from Dolni Vestonice, 29,000 to 22,000 years BP (Potvin, 2024).

Wood firing is one of the oldest ceramic techniques, dating back to prehistoric times. This process, which involves the use of fire to fire clay, has evolved across cultures and regions around the world, each bringing its own unique style to the firing process. Wood firing dates back to the Neolithic period (about 10,000 years ago). The first ceramics were made in primitive pits (Figure 2), where the clay was first shaped by hand and then fired in open fires.

In Mesopotamia, Egypt, and modern-day China, wood-firing was used to produce pottery for ritual, utilitarian, and decorative purposes (Beck, Hill, & Khandelwal, 2022; Bozdemir, 2024; Gardner, Karkanas, Müller, Freestone, & Kiriati, 2025). The oldest examples date back to the 4th millennium BC. Such techniques were also known and used in ancient Peru on the Andean coast (Shimada, Goldstein, Sosa, & Wagner, 2003). Egypt was famous for its earthenware products fired in simple kilns. The clay was often coated with colored glazes obtained by reaching high temperatures.

China pioneered the development of wood-firing, reaching extremely high temperatures that allowed the production of porcelain as early as the Shang Dynasty (1600–1046 BC). Chinese ceramists also invented multi-chamber kilns, known as

“dragon kilns,” which allowed for more even heat distribution (Wang et al., 2018; Karasu, Andaş, & Ak, 2019; Li, Shen, Zheng, & Wang, 2021; Fang, 2023).



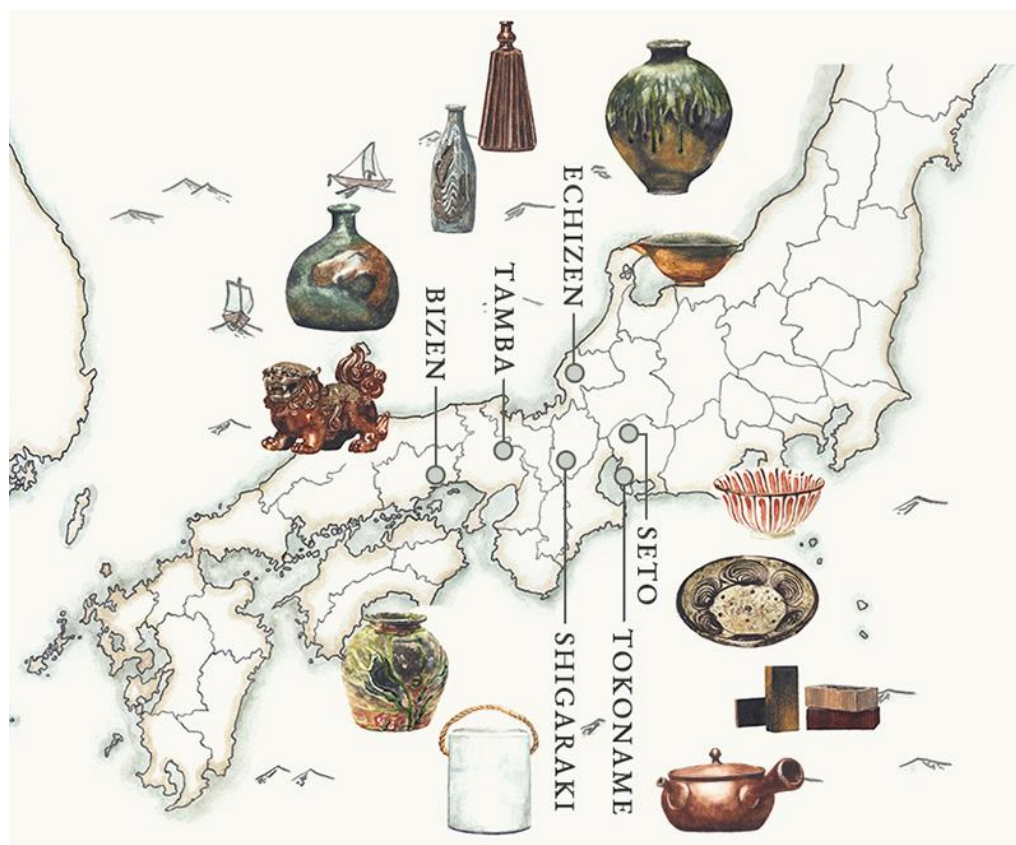
**Figure 2.** Primitive pottery pit (Brooke, n.d).

In Greece and Rome, the wood-firing technique was widely used to make amphorae, vases, and sculptures. Greek ceramists created the famous black and red figured vases, using special kilns to control the oxidation process and restore the colors during firing (Jones, 2021). Black-on-red painted pottery is one of the most characteristic typological groups that appeared during the final phases of the Late Neolithic (4800/4700–3900/3800 BC) in northern Greece (Kilikoglou et al., 2007). The Romans later adopted this technology and made it widespread.



**Figure 3.** A typical two-handle pot Ancient Greek ceramics (Kilikoglou et al., 2007).

Japan is a pottery powerhouse, boasting an abundance of ceramic production sites all over the country (Web Japan, n.d.). Among these, the six regions of Echizen, Seto, Tokoname, Shigaraki, Tamba, and Bizen – known as the “Six Ancient Kilns” – are said to have been active for more than 1000 years, and were registered as Japan Heritage sites in 2017 (Figure 4).



**Figure 4.** A location map of the “Six Ancient Kilns” (Web Japan, n.d.).

In Japan, wood-fired pottery was particularly developed through the use of Anagama and Noborigama kilns. Among the most famous examples are ceramics from the Momoyama period (1573–1615) (Kilikoglou et al., 2007; Keulemans, 2016; Bergmann, 2020). Japanese craftsmen particularly valued the natural ash glazes that resulted from prolonged firing, which gave the products an organic, natural beauty (Figure 5).

In medieval Europe, ceramics developed through techniques borrowed from the Middle East and China (Qiumei, 2023; Han, Zheng, & Wu, 2021). Wood-fired kilns were used to produce pottery and building materials. In particular, traditional wood-fired kilns such as a Borne kiln in France, the Cassel kiln in Germany and the Newcastle kiln in England were used (Olsen, 2001, p. 59). These kilns often had a multi-chamber design, which allowed firing a large number of products simultaneously. Salt glazes, which were formed as a result of firing with the use of salt, were also popular.



**Figure 5.** Kuro-Oribe tea bowl (Mino ware, cylindrical form, “Fuyugare”, Momoyama period (1573–1615), 16<sup>th</sup> century, Stoneware, h. 9.2 cm, d. 10.2 cm. (Kilikoglou et al., 2007).

In Ukraine, kilns were first discovered at the sites of the Trypillia, Chernyakhiv and other cultures (Rud, Zaitseva, Hofmann, Rauba-Bukowska, & Kosakivskyi, 2019; Nikitin, Videiko, Patterson, Renson, & Reich, 2023; Rybicka & Havinskyi, 2023). According to scientists, there were two types of kilns – pottery kilns and pottery horns. These structures differ not only in structure but also in firing technology. Pottery kilns are single-chamber heat-technical structures with a permanent ceiling over the internal volume of the chamber itself, in which the dishes for firing are simultaneously placed and the fire is kindled. Pottery horns are two-chamber heat-technical structures, the upper chamber is called the firing or dish chamber, in which clay products for firing are placed, the lower chamber is the kiln chamber for kindling the fire (Figure 6).



**Figure 6.** Vyshgorod (Ukraine). Pottery Museum. Pottery horn (Vyshgorod Historical and Cultural Reserve, n.d.).

In the 21st century, wood firing has gained new significance with the studio pottery movement. Potters around the world have revived traditional firing techniques, experimenting with the textures and effects that result from firing clay under the influence of wood and ash. In the United States and Europe, many artists have begun to use wood firing as a form of artistic expression, focusing on natural results that cannot be reproduced using gas or electric kilns.

The aim of the work is a comprehensive study that covers the historical, technical and creative aspects of the unique process of wood firing ceramics, and focuses on the peculiarities of the construction of ancient cross-flow kilns.

### **Research Methodology.**

Studies in the history of science and technology help to see how people in different eras have tried to understand the world and change it with the help of knowledge. They show that many things that seem familiar today were once revolutionary discoveries. Such studies allow to trace how scientific approaches, technical solutions, and engineering thinking were gradually formed (Feng & Liu, 2024; Latsik, Markovych, Hryhoruk, Bazhanov, & Matsyshina, 2024; Strelko, 2021). They also allow to better understand the relationship between science, society, and culture. To investigate this, scientists use historical documents, archives, old drawings, and personal letters of scientists and engineers (Grifa et al., 2021; Pongwisuthiruchte & Potiyaraj, 2025; Strelko et al., 2019). They often also analyze artifacts – from ancient tools to industrial equipment. One important method is to compare the development of the same idea or technology in different countries or eras. Researchers also communicate with modern scientists and technicians to better understand the essence of certain processes. Such interdisciplinary approaches allow to combine knowledge from history, science, technology, and philosophy (Andriiashko, Bilyk, & Kostiukova, 2022; Khyzhynskiy, Lampeka, & Strilets, 2024; Shelyagin et al., 2021). As a result, we get a holistic picture of how humanity learned to think, build, discover, and rethink the world around us.

In this study, we tried not only to describe the history of wood-fired ceramics, but also to understand more deeply how this technology developed in different cultures and why it retains its significance even today. To achieve this, we used several approaches and methods that helped collect, analyze, and summarize information.

First of all, a significant number of sources were processed – from scientific articles, archaeological reports and monographs to publications by contemporary ceramists. We focused on texts that relate to the history of ceramics in the context of wood-firing technology, as well as studies of individual regions (e.g. Japan, China, Europe). This made it possible to trace how the technique changed over time and under what conditions its local variants emerged.

We compared examples of wood-firing from different eras and countries, paying attention to kiln designs, types of wood, firing duration, and ways of placing products in the kiln. This helped to see both common features (e.g. the use of ash as a natural

glaze) and culturally specific differences that reflect local traditions and ideas about beauty.

Since the result of wood-firing is always unique, we carefully studied photographs and descriptions of ceramic products created at different times. Color, texture, ash streaks, flame traces were evaluated – everything that helps to understand the specifics of this type of firing. In some cases, data from museum catalogs and online archives were used.

Particular attention was paid to the experience of modern ceramists working with wood-fired kilns. Personal blogs, interviews and video materials were analyzed, in which masters share their vision of the process, difficulties and creative results. This allowed to combine a historical perspective with real practical experience.

To clarify individual technical points (for example, temperature regimes, types of kilns, chemical processes in glaze), we consulted with specialists in the field of ceramics, materials technology and art history.

In general, the work combined historical, cultural and technical approaches. This allowed for a comprehensive consideration of wood firing not only as a method of firing clay, but as an important cultural phenomenon that connects man, nature, and fire in the process of creation. Catalogs, websites, and personal pages of artists involved in wood firing ceramics also became important sources of information.

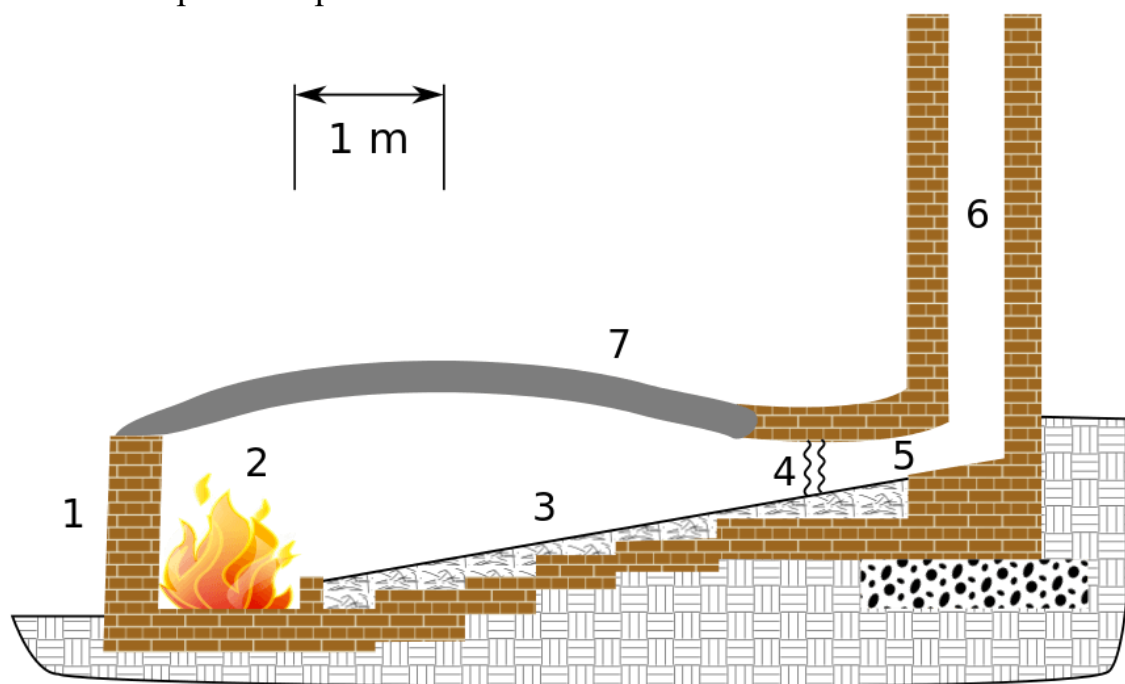
### **Results and Discussion.**

Crossdraft kilns are classified by the movement of fire from a firebox in one part of the kiln, through a chamber to an outlet in the opposite part (Olsen, 2001; Lu et al., 2012; Ma, Henderson, Evans, Ma, & Cui, 2021). The most common kiln types are the single-chamber kiln, the cave kiln, the stepped tunnel kiln, and the flat tunnel kiln. Crossdraft kilns originated in the Far East.

The exact location and time are unknown, but scholars suggest that ceramists in China, Korea, and Japan invented similar kilns, known as hole kilns, at about the same time (Lu et al., 2012; Li, 2015; Ma, Henderson, Evans, Ma, & Cui, 2021). Hole kilns were used during the Asuka period in Japan, the Sui Dynasty (581–618 AD) in China, and the Silla period in Korea. In Japan, they were called "anagama", where "ana" means hole or cutout, and "gama" means kiln (Figure 7).

Kilns of this type were built directly inside the clay deposits. A hole was dug in the clay hill, an expanded firebox was formed inside the hill, which narrowed again, turning into a chimney. After forming such a kiln, the drying process of the structure took place. The next stage was the first firing of the empty kiln, a fire was continuously burned in the kiln for several days, gradually increasing its intensity until the inner walls of the kiln became strong (burnt to scrap). The Anagama kiln is characterized by the lack of physical separation between the combustion chamber and the firing chamber. Firing wood creates a high temperature and a unique glaze on each product. Firing in an Anagama kiln with wood is important for creating unique ceramic products. A large amount of wood was used during the process, which led to intense

burning and the generation of high temperatures of over  $760^{\circ}\text{C}/1400^{\circ}\text{F}$  (Ceramicartis, n.d.). The wood was burned, and the resulting ash was drawn through the chamber into the chimney. This ash settled on the ceramic products, creating a unique glaze on each of them. The presence of ash in this Japanese kiln significantly influenced the final result of the ceramic products. The chemical composition of the ash, combined with the high temperatures, led to complex chemical reactions on the surface of the product. This process created vitrification effects, creating glazes with unique colors and textures on each product, which gave the ceramics fired in the Anagama kiln a special imprint.



**Figure 7.** Anagama: The traditional kiln of Japanese ceramics. 1 – door approximately 75 cm wide; 2 – firebox; 3 – stacking platform made of silica sand. here the unfired pieces are placed; 4 – two dampers, one for firing and the second for closing the chimney hermetically; 5 – flue; 6 – fireplace 3 meters high; 7 – cast arc, made of heat-resistant (castable) cement (Ceramicartis, n.d.).

Among the cross-flow kilns, the following striking examples can be distinguished. The Tamba tube kiln, which is considered one of the oldest kilns in Japan (Geisinger, 2010; Lee, 2024). Over the past 650 years, the design of the kiln and the firing process in it have remained unchanged and are protected by the Japanese government as cultural heritage. The Tamba kiln, consisting of 23 interconnected segments, was built in the early Kamakura period (1185–1392) by potters who had emigrated from Korea and were engaged in the production of ceramics in the Tachikui region of Japan (Olsen, 2001, p. 50). These potters were tasked with designing a kiln that could simultaneously fire 500 large storage vessels (approximately 65 cm high). The solution was to extend the standard Anagama kiln design to approximately 36.5 m

in length and to build a kiln dome above the ground, forming a chimney filled with ceramics (Figure 8).



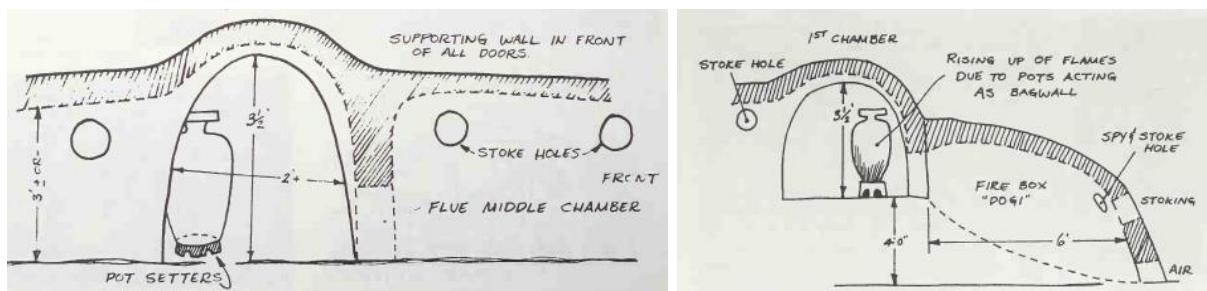
**Figure 8.** Kiln pipe Tamba (Japan Travel by NAVITIME, n.d.).

Tamba kilns are of the anagama type, tunnel kilns dug into the hillside, using natural draft to distribute heat evenly. Tamba kilns have a sloping tunnel that allows fire and hot air to move naturally up the slope. They often had multiple chambers for longer firing times. Pottery in such kilns was fired unglazed or with a natural glaze that was formed by ash deposits and chemical reactions at high temperatures.

The wares in such Tamba kilns were placed in rows between side openings. Olsen described the design features of this kiln as follows (Olsen, 2001, pp. 50–51):

*“Proper loading of the kiln was already an important step, as it played a significant role in the movement of the fire through the kiln during firing. The kiln loader had to crawl inside through the firebox and gradually fill it with wares, starting from the far section. Between the sections, a free space was left for burning wood, which was thrown through the side openings. The design of the kiln allowed the fire to move freely through the pipe thanks to internal chimneys before entering each individual section. The firebox is located in front of the internal chimney in the first section (Figure 9). The firing process began with a small hearth at the edge of the kiln, which gradually increased to accumulate coal, which was slowly pushed into the kiln with a long metal tool. The filling of the kiln took place over 36 hours, which raised the temperature of the first 4 sections to 1000 °C, at this stage the main firebox became an opening for oxygen access, and the addition of*

firewood for burning took place through the side openings in the following sections. It was considered that the required temperature was reached in each individual section when a column of flame of approximately 30 cm emerged from the chimney, after which the flame was allowed to burn out and moved to the next section. Firing continued until the side openings of all sections were filled and the required temperature was reached, due to which a large amount of ash deposits and other fiery effects accumulated on the products. Then the kiln was preserved for slow cooling”.



**Figure 9.** Tamba kiln design (Olsen, 2001, pp. 52–53).

Ceramics made in Tamba kilns have always been valued for their natural, “alive” appearance – ash deposits, flame-induced color changes, dark and reddish tones (Figure 10). This is the effect of the so-called yo-hen – natural variation that is not fully controllable. Today, Tamba kilns are still used by craftsmen who strive to preserve traditional techniques. At the same time, they combine old methods with modern forms, creating works that are valued all over the world. Products from Tamba kilns reflect the aesthetics of wabi-sabi – an appreciation of the imperfect, the changing, the natural. Each piece is unique, with the imprint of the action of fire and smoke.



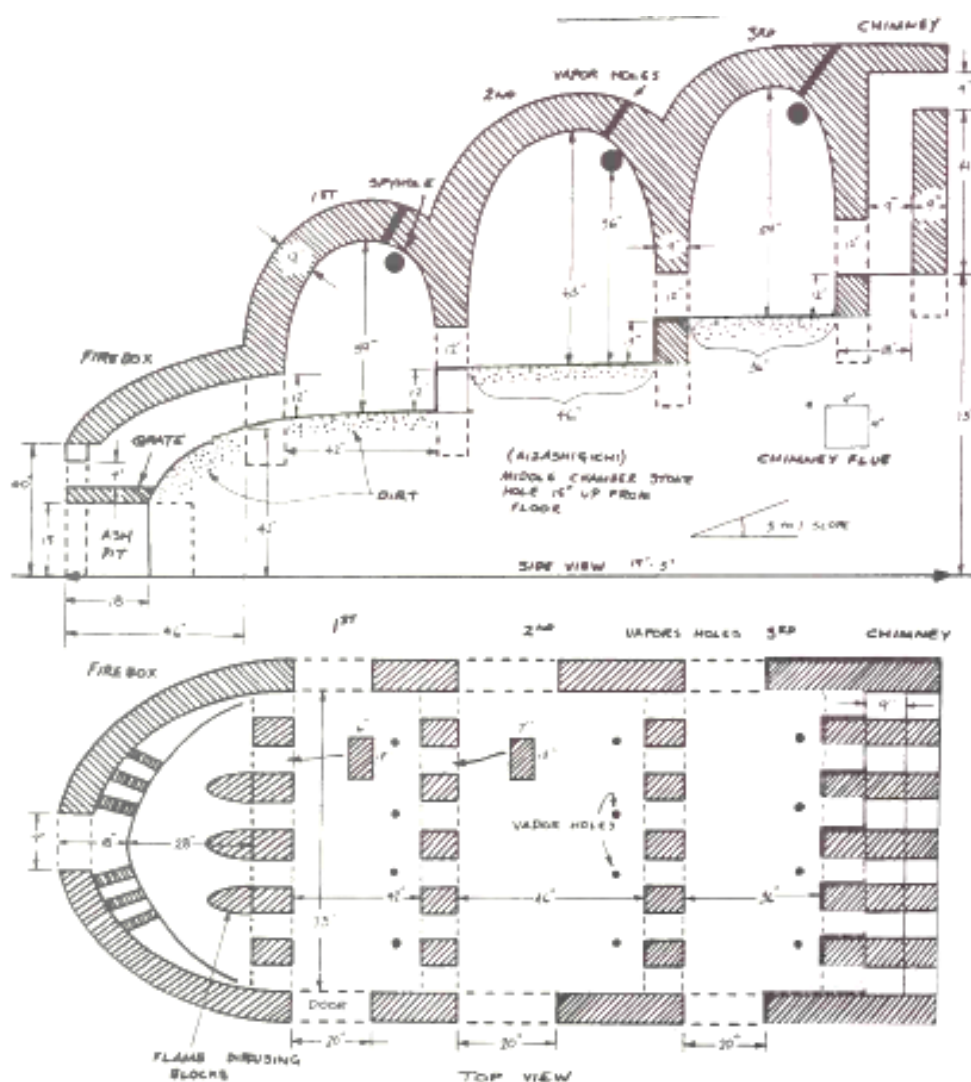
**Figure 10.** Ceramics made in Tamba kilns (Japan Travel by NAVITIME, n.d.).

Climbing Chamber Kilns are considered the next step in development after the Tamba kiln, as each section of the kiln became a separate “cave”, which allowed for more controlled firing conditions and denser loading (Figure 11). The classic “Climbing Chamber Kiln”, or noborigama/dragon kiln, is a multi-chamber, inclined kiln, the structure of which “climbs” up the slope and thereby efficiently uses the heat. Such a kiln was built on a slope with an inclination of approximately 10–16° to effectively use the force of hot air draft. They were developed in China during the Sung Dynasty (960–1279) to assist in the firing of Tenmoku tea bowls in Chienyao, Hohnan and other sites and Celadon wares in the North. The Climbing Chamber Kiln consists of supports and chambers: firewood is burned in the lower chamber, the heat gradually passes through the partitions to the upper chamber, transferring heat – a downdraft design with a counter-flow mechanism.



**Figure 11.** Climbing kiln scheme (Musubi Kiln, 2025).

Each cave had a double radius arch, and the highest point of the arch was shifted to the rear, which slightly complicated the movement of the fire flow and created a reduction atmosphere when the kiln was fired correctly (Olsen, 2001, p. 77). Hot air from the lower chambers heated the upper ones, and the chimney heated the supplied air – this provided a noticeable economy in the use of firewood for fuel. To carry out the firing in the reduction section, it was necessary to constantly maintain a fast rate of firewood supply to maintain a large amount of coal in the kiln. The middle sections had a less radical arch, which facilitated the movement of the fire and contributed to oxidizing conditions (Figure 12). The design of such a kiln provided the possibility of reaching temperatures of 1300–1400°C, with long firings – 2–3 days in a row or even more than a week. By adding firewood separately in each chamber, it was possible to create an oxidizing or reducing environment – this made it possible to simultaneously fire clay products with and without glaze.



**Figure 12.** Kyoto Bidai climbing kiln (Olsen, 2001, p. 78).

The noborigama kiln itself is a hybrid of architectural engineering, thermodynamic efficiency and artistic unpredictability (Figure 13). It is a bridge between nature (wood fire), traditional craftsmanship and ceramic aesthetics. Although this approach currently requires significant resources and space, for true connoisseurs of the natural wood-fire spirit, the noborigama is an indispensable tool (Figure 14).

The Bizen kiln is unusual in both function and design when compared to other Japanese kilns, and is only indigenous to the Imbe region of Okayama prefecture in central Japan (Olsen, 2001, p. 83). The features of such a kiln are a large firebox, which allows to increase the surface of direct contact of products with fire, as well as a small air flow in the kiln chamber, which allows to accumulate a large amount of ash, maximized efficiency of wood use during seven-day firing and minimized heat loss during a gradual increase in temperature (Figure 15).

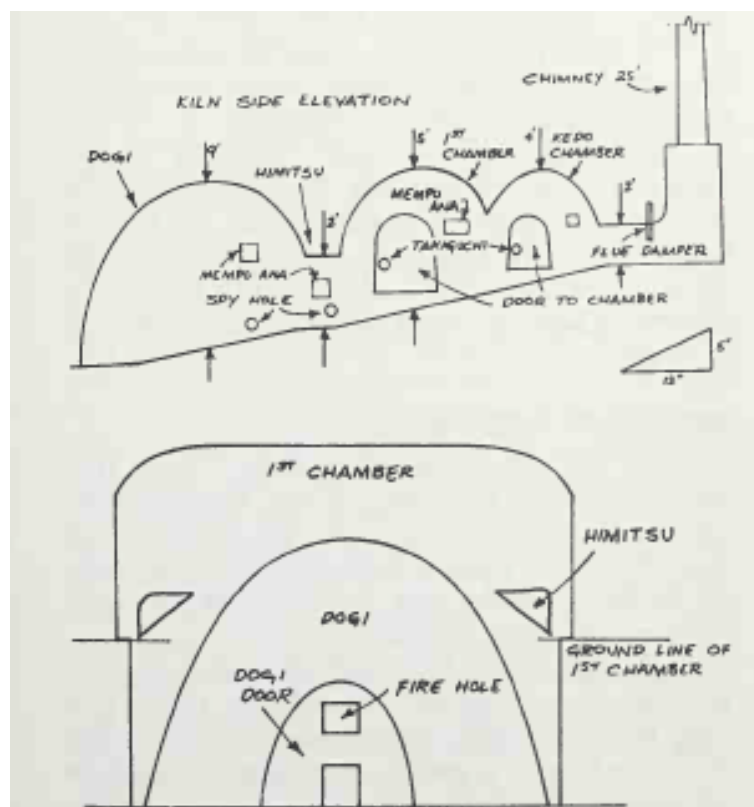


**Figure 13.** Le Sanpei Climbing Kiln's noborigama (Musubi Kiln, 2025).



**Figure 14.** Unloading Le Sanpei Kiln's noborigama. Under the electric light, white porcelain glistens atop a column of saggar boxes (Musubi Kiln, 2025).

The hearth of the Bizen kiln is the most open of all Japanese kilns and is the first and most important chamber (Olsen, 2001, p. 84). There is no filling from the hearth to the chimney of the next chamber, only a gradual slope that is interrupted about halfway (Figure 15).



**Figure 15.** Front and side elevations of the Bizen kiln (Olsen, 2001, p. 85).

This step in the kiln actually consists of shelves on which the wares are also placed. They receive direct contact with the flame and a strong reducing atmosphere containing ash to form a natural ash coating (Olsen, 2001, pp. 83–85). The walls of the Bizen kiln are 25 to 33 cm thick, built tightly, without steam holes and insulated with a layer of a mixture of refractory clay, straw and earth. This thick and dense construction reduces heat loss and ensures intensive heating during a gradual increase in temperature with minimal fuel consumption. Expansion and contraction of the kiln are balanced by the extremely long and gradual firing and cooling cycle. Between the firebox and the first chamber is a 61 cm long chimney, which contains a small chamber called the himitsu, or "secret chamber". The chimney openings leading into the himitsu are very small – 7.5×15 cm, which increases the speed of draft through it to the first chamber. In the himitsu, small items such as tea cups and sake bottles are placed. This chamber is well suited for intensive contact with the flame and ash, since its small size and chimney openings force the fire to pass through the items with a high cross-draft speed. The chimney openings lead from the himitsu to the first chamber. This allows the rapid draft created by the himitsu chimney openings to pass unhindered into the

first chamber, without creating back pressure in the himitsu. After entering the first chamber, the draft slows down significantly due to the large volume of the chamber. This chamber has built-in side openings for the takiguchi fire, which help to increase the temperature and create active contact with the flame not only in the lower part, but also in the upper part of the chamber. The second chamber, the kedo, is much lower in height and smaller in width. This chamber does not use shelves; all products are placed on the floor or on top of each other. The chamber has an additional firebox, which, if necessary, is used to increase the temperature.

Ancient Bizen technologies find their new reflection in the works of modern craftsmen. The famous traditional Japanese Bizen ceramic ware is made by firing a certain type of green clay in a wood-fired kiln at a temperature of approximately 1200 °C (Kusano et al., 2021). Bizen ceramics are a simple and unglazed type of ceramics that express two deep and important Japanese concepts: wabi (demonstration of wealth and beauty combined with simplicity or poverty) and sabi (aesthetic sense of solitude). For this reason, great tea masters often used this type of pottery. Bizen pottery is considered an art form that involves the use of both clay and flame, as a variety of colors and patterns can be obtained in the finished products without the aid of artificial glazing or painting (Figure 16).



**Figure 16.** Traditional Japanese Bizen stoneware produced by Kenji Matsushima, a master Bizen potter. This item had a base and was fired in a firewood kiln (Kusano et al., 2021).

The tradition of wood-fired ceramics was best studied and developed in East Asian countries. Among them are sources on the history of pottery and porcelain in East Asian countries, in particular China, Korea, Japan (Rehren & Yin, 2012; Morito, 2022; Wilson, 2023) and Central Asia (Choriyev, Shaydullaeva, & Raxmonkulova, 2023). Important sources were information about wood-fired, types and designs of kilns, and manuals with advice on wood-fired technology. Recent research and publications on wood-firing ceramics have highlighted several key aspects of the development of the technique, including: wood firing can produce unique aesthetic results, as it creates unique colors, textures, and natural glazes from the ash deposited on the ware during firing. The unpredictability of the process and its impact on the finished product make the technique very attractive to artists, as each piece is unique. The results are influenced by various factors, such as the type of wood, the design of the kiln, and temperature control.

Although wood firing is often associated with randomness, modern craftsmen can predict the results with considerable accuracy through the use of new technologies, such as digital pyrometers and oxyprobes. This allows for the creation of high-quality products with minimal waste. Wood-firing raises environmental issues, including carbon emissions. While the technique itself is not the biggest polluter, modern ceramists are beginning to look for ways to reduce emissions and develop more environmentally friendly approaches to firing.

### **Conclusions.**

Different types of cross-flow kilns for wood-fired ceramics are analyzed, and key kiln designs used in different historical periods and regions of the world are considered. Each of these kilns has its own characteristics that determine the method of temperature control, heat distribution, and firing results. Despite the different design solutions, all of these kilns had a common goal: achieving high temperatures to create strong, waterproof ceramics. The wood-fired process highlights its complexity and uniqueness, based on many variables that determine the final appearance of the products. Wood-firing is not only a technical process, but also a creative art, where every decision affects the result. At different stages of firing – from the initial temperature increase to the final phase of maintaining high temperature – it is important to control the rate of temperature increase, especially when passing through silica inversions (quartz and cristobalite), in order to avoid destruction of the products. Precise control of the temperature and atmosphere in the kiln (oxidative or reductive) allows for the achievement of various aesthetic effects, such as natural ash deposition, the formation of glossy or matte surfaces, and color effects.

An analysis of the historical development of wood firing has revealed its deep roots in the cultural traditions of different peoples. This technique, which originated thousands of years ago, remains relevant due to its ability to create unique textures, effects, and emphasize the natural beauty of the material. The historical aspect shows how wood firing has evolved from a utilitarian process into an important artistic tool.

A study of types of wood-fired kilns, such as Anagama, Noborigama, and others, has revealed their technical features and their influence on the final result. It has been established that the firing process depends on many factors, including the type of wood, the kiln atmosphere, the temperature, and the duration of firing. These parameters form the unique character of each product.

An essential element of successful firing is the time and duration of each stage. Decisions about the duration of high-temperature firing and the rate of cooling directly affect the texture and color of the glazed surfaces. Accordingly, to achieve certain effects, such as the glossy green sheen of a natural ash glaze or complex matte surfaces, the cooling process must be carefully planned.

Thus, wood firing is a complex process, where every choice – from the type of wood to the cooling strategy – creates a unique result.

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### **Conflict of interest.**

The authors declare no conflict of interest.

## **References**

- Alykow, K., Bednarz, Ł., Piechówka-Mielnik, M., Napiórkowska-Alykow, M., & Krupa, M. (2022). New ceramic tiles produced using old technology applied on historic roofs – Possibilities and challenges. *Materials*, 15(21), 7835. <https://doi.org/10.3390/ma15217835>
- Andriiashko, V., Bilyk, M., & Kostiukova, V. (2022). Emergence and development of the Kyiv school of artistic textiles in the XX century. *History of Science and Technology*, 12(1), 69–87. <https://doi.org/10.32703/2415-7422-2022-12-1-69-87>
- Beck, M. E., Hill, M. E., & Khandelwal, M. R. (2022). How to keep the home fires burning: A comparative study of cooking hearths for ceramic vessels. *Ethnoarchaeology*, 14(1), 1–29. <https://doi.org/10.1080/19442890.2022.2084236>
- Bergmann, A. (2020). Goshomaru: Kabuki Zeitgeist in Tea Bowls. *The Journal of Asian Arts & Aesthetics*, (6), 33–45. [https://doi.org/10.6280/JAAA.2020.05\\_\(6\).0004](https://doi.org/10.6280/JAAA.2020.05_(6).0004)
- Bozdemir, O. (2024). The history and future of ceramic sculpture: from ancient clay figures to modern 3D printing. *Gaziantep University Journal of Social Sciences*, 23(2), 420–436. <https://doi.org/10.21547/jss.1383449>
- Brooke, B. (n.d). Pottery in the Ancient World. *The Antiques Almanac*. Retrieved from <http://theantiquesalmanac.com/potteryintheancientworld.htm>

- Ceramicartis. (n.d.). Anagama: The traditional kiln of Japanese ceramics. *Ceramicartis*. Retrieved from <https://ceramicartis.com/en/anagama-traditional-japanese-kiln/>
- Choriyev, S., Shaydullaeva, G., & Raxmonkulova, Z. (2023). The history of archives in Central Asia: ancient times. *History of Science and Technology*, 13(1), 34–51. <https://doi.org/10.32703/2415-7422-2023-13-1-34-51>
- Fang, L. (2023). Ceramics of the Xia and Shang Dynasties. In *The History of Chinese Ceramics* (pp. 65–90). Singapore: Springer Nature Singapore. [https://doi.org/10.1007/978-981-19-9094-6\\_2](https://doi.org/10.1007/978-981-19-9094-6_2)
- Feng, H., & Liu, J. (2024). Recognition and classification of ceramic sculpture styles based on pattern recognition and intelligent systems. In *Third International Conference on Electronic Information Engineering, Big Data, and Computer Technology (EIBDCT 2024)* (Vol. 13181, p. 1318103). Beijing, China: SPIE. <https://doi.org/10.1117/12.3031356>
- Gardner, C., Karkanis, P., Müller, N. S., Freestone, I. C., & Kiriati, E. (2025). Wood ash tempering in archaeological ceramics: An experimental approach for its characterisation using textural, chemical, and mineralogical analysis. *Journal of Archaeological Science*. <https://dx.doi.org/10.2139/ssrn.5141750>
- Geisinger, B. (2010). *Potters of Japan: Another look at the timeless art of Nine Families*. Sebastopol, CA: BillGeisinger Studio.
- Grifa, C., Germinario, C., Mercurio, M., Izzo, F., Pepe, F., ... & Langella, A. (2021). Technology, exploitation and consumption of natural resources of traditional brick productions in Madagascar. *Construction and Building Materials*, 308, 125022. <https://doi.org/10.1016/j.conbuildmat.2021.125022>
- Han, G., Zheng, N., & Wu, J. (2021). Ceramic art reality in the context of technology history. *Cultural and Religious Studies*, 9(7), 321–337. <https://doi.org/10.17265/2328-2177/2021.07.002>
- Japan Travel by NAVITIME. (n.d.). A famous spot in the "Land of Tamba Pottery" where you can also experience pottery making. *Japan Travel by NAVITIME*. Retrieved from <https://japantravel.navitime.com/en/area/jp/spot/02301-13000255/>
- Jones, R. (2021). The decoration and firing of ancient Greek pottery: a review of recent investigations. *Advances in Archaeomaterials*, 2(2), 67–127. <https://doi.org/10.1016/j.aia.2021.07.002>
- Karasu, B., Andaş, Ü. M., & Ak, G. (2019). Celadon Glazes. *El-Cezeri*, 6(2), 388–413. <https://doi.org/10.31202/ecjse.530520>
- Keulemans, G. (2016). The geo-cultural conditions of kintsugi. *The Journal of Modern Craft*, 9(1), 15–34. <https://doi.org/10.1080/17496772.2016.1183946>
- Khyzhynskiy, V., Lampeka, M., & Strilets, V. (2024). The history of the development of 3D printing technologies and their use in world artistic ceramics. *History of Science and Technology*, 14(1), 152–183. <https://doi.org/10.32703/2415-7422-2024-14-1-152-183>

- Kilikoglou, V., Grimanis, A. P., Tsolakidou, A., Hein, A., Malamidou, D., & Tsirtsoni, Z. (2007). Neutron activation patterning of archaeological materials at the National Centre for Scientific Research ‘Demokritos’: the case of black-on-red Neolithic pottery from Macedonia. *Archaeometry*, 49(2), 301–319. <https://doi.org/10.1111/j.1475-4754.2007.00303.x>
- Kusano, Y., Nakata, H., Peng, Z., Maki, R. S., Ogawa, T., & Fukuhara, M. (2021). Studying and utilizing traditional technologies: microstructure and formation mechanism of  $\epsilon$ -Fe<sub>2</sub>O<sub>3</sub> on traditional Japanese Bizen Stoneware. *ACS Applied Materials & Interfaces*, 13(32), 38491–38498. <https://doi.org/10.1021/acsami.1c09394>
- Latsik, Y., Markovych, M., Hryhoruk, N., Bazhanov, M., & Matsyshina, Z. (2024). History of the development of theater architecture: (5th century BC – beginning of the 20th century). *History of Science and Technology*, 14(1), 254–283. <https://doi.org/10.32703/2415-7422-2024-14-1-254-283>
- Lee, S. (2024). *Crafting rural Japan: Traditional potters and rural creativity in regional revitalization*. London: Taylor & Francis. <https://doi.org/10.4324/9781003326540>
- Li, W. (2015). Ceramics technology. In: Lu, Y. (Ed.), *A history of Chinese science and technology* (Vol. 2, pp. 301–378). Berlin, Heidelberg: Springer. [https://doi.org/10.1007/978-3-662-44166-4\\_3](https://doi.org/10.1007/978-3-662-44166-4_3)
- Li, Y., Shen, Y., Zheng, J., & Wang, G. (2021). Comparative microstructural study of celadon excavated from Housi’Ao kiln site in China (late Tang and Five dynasties): Mi-se porcelain and ordinary Yue Celadon. *Journal of the European Ceramic Society*, 41(16), 430–440. <https://doi.org/10.1016/j.jeurceramsoc.2021.08.050>
- Lu, X., Li, W., Luo, H., Han, L., Wang, H., & Li, Q. (2012). A scientific study on the Xing kiln of ancient China. *Science China Technological Sciences*, 55, 2902–2919. <https://doi.org/10.1007/s11431-012-4960-0>
- Ma, H., Henderson, J., Evans, J., Ma, Q., & Cui, J. (2021). Searching for the earliest use of limestone as a flux in Chinese high-fired ceramic glazes—evidence from Sr isotopic analysis of Chinese northern porcelain. *Journal of Archaeological Science*, 131, 105395. <https://doi.org/10.1016/j.jas.2021.105395>
- Morito, Ya. (2022). *A holistic approach to ceramic sculpture: Its history, theory, and materiality*. Newcastle upon Tune, UK: Cambridge Scholars Publishing.
- Musubi Kiln. (2025, March 17). The enigmatic science of Japanese climbing kilns. *Musubi Kiln*. Retrieved from <https://musubikiln.com/blogs/journal/the-enigmatic-science-of-japanese-climbing-kilns>
- Nikitin, A. G., Videiko, M., Patterson, N., Renson, V., & Reich, D. (2023). Interactions between Trypillian farmers and North Pontic forager-pastoralists in Eneolithic central Ukraine. *PLoS One*, 18(6), e0285449. <https://doi.org/10.1371/journal.pone.0285449>

- Olsen, F. L. (2001). *The Kiln book: Materials, specifications & construction* (3rd edition). Wisconsin, USA: Krause Publications.
- Pongwisuthiruchte, A., & Potiyaraj, P. (2025). Challenges and innovations in sustainable 3D printing. *Materials Today Sustainability*, 31, 101134. <https://doi.org/10.1016/j.mtsust.2025.101134>
- Potvin, Y. (2024). “Creative Anthropology” as a unit for knowing: epistemic object and experimental system in Research-Creation “in” Clay. *Humans*, 4(1), 108–130. <https://doi.org/10.3390/humans4010007>
- Qiumei, Q. (2023). A literature review on the origin of ceramics. *International Journal of Latest Research in Humanities and Social Science*, 6(8), 309–315. Retrieved from <http://www.ijlrhss.com/paper/volume-6-issue-8/31-HSS-2224.pdf>
- Rehren, T., & Yin, M. (2012). Melt formation in lime-rich proto-porcelain glazes. *Journal of Archaeological Science*, 39(9), 2969–2983. <https://doi.org/10.1016/j.jas.2012.04.050>
- Rud, V., Zaitseva, O., Hofmann, R., Rauba-Bukowska, A., & Kosakivskyi, V. (2019). Unique pottery kiln construction? The interpretation of massive clay objects from the Trostianchyk site of the Trypillia culture. *Sprawozdania Archeologiczne*, 71, 11–39. <https://doi.org/10.23858/SA71.2019.001>
- Rybicka, M., & Havinskyi, A. (2023). Trypillia culture pottery imports with attributes of the latest phase of the Trypillia CII stage in the Funnel Beaker culture settlement Zymne, western Ukraine. *Sprawozdania Archeologiczne*, 75(1), 35–49. <https://doi.org/10.23858/SA/75.2023.1.3473>
- Shelyagin, V., Bernatskyi, A., Siora, O., Nabok, T., Shamsutdinova, N., & Sokolovskyi, M. (2021). Historical review of technological CO<sub>2</sub> lasers development, manufacturing and operation stages at E. O. Paton Electric Welding Institute of the NAS of Ukraine. In *2021 IEEE 3rd Ukraine Conference on Electrical and Computer Engineering (UKRCON)* (pp. 589–593). Lviv, Ukraine: IEEE. <https://doi.org/10.1109/UKRCON53503.2021.9575940>
- Shimada, I., Goldstein, D., Sosa, J., & Wagner, U. (2003). Early pottery making in northern coastal Peru. Part II: Field firing experiments. *Hyperfine Interactions*, 150, 91–105. <https://doi.org/10.1023/B:HYPE.0000007356.66809.26>
- Strelko, O. (2021). Stages of development, improvement and application of equipment for welding in space, created with the participation of Ukrainian scientists. *Studia Historiae Scientiarum*, 20, 263–283. <https://doi.org/10.4467/2543702XSHS.21.010.14041>
- Strelko, O., Pylypchuk, O., Berdnychenko, Yu., Hurinchuk, S., Gamaliia, V., & Sorochnytska, O. (2019). Historical milestones of electrotechnical equipment creation for active experiments in the near-earth space by Ukrainian scientists. In *Proceeding's 2019 IEEE 2nd Ukraine Conference on Electrical and Computer Engineering, UKRCON 2019* (pp. 1229-1234). Lviv, Ukraine: IEEE. <https://doi.org/10.1109/UKRCON.2019.8879983>

- Vyshgorod Historical and Cultural Reserve. (n.d.). Pottery Museum. *Vyshgorod Historical and Cultural Reserve*. Retrieved from <https://www.vikz.org.ua/pro-vikz-muzei-davnoruskogo-goncharstva.html>
- Wang, M., Zhu, T., Ding, X., Hui, Z., Wu, F., Liu, C., & Sun, W. (2018). Composition comparison of Zhejiang Longquan celadon and its imitation in Dapu kiln of Guangdong in the Ming Dynasty of China (1368–1644 CE) by LA-ICP-MS. *Ceramics International*, 44(2), 1785–1796. <https://doi.org/10.1016/j.ceramint.2017.10.112>
- Web Japan. (n.d.). The thousand-year legacy and evolution of the “Six Ancient Kilns”. *Web Japan*. Retrieved from [https://web-japan.org/trends/11\\_food/jfd202112\\_six-ancient-kilns.html](https://web-japan.org/trends/11_food/jfd202112_six-ancient-kilns.html)
- Wilson, R. A. (2023). Authenticity, Legitimacy, and mimesis in the production and use of Chinese-Inspired Japanese Tea ceremony utensils: Karamono (Chinese Things). In A. Hein, Ch. J. Foster (Eds.), *Understanding Authenticity in Chinese Cultural Heritage* (pp. 202–217). New York: Routledge. <https://doi.org/10.4324/9781003290834-17>

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## **Історичне підґрунтя дров'яного випалу кераміки в печах перехресного потоку**

*Анотація.* Дана робота є комплексним дослідженням, яке охоплює історичні, технічні й творчі аспекти унікального процесу дров'яного випалу кераміки. Проведене дослідження дозволило глибше зрозуміти суть дров'яного випалу, його естетичну та культурну цінність. Аналіз історичного розвитку дров'яного випалу виявив його глибокі корені в культурних традиціях різних народів. Ця техніка, що виникла тисячоліття тому, залишається актуальною завдяки своїй здатності створювати унікальні текстури, ефекти й підкреслювати природну красу матеріалу. Історичний аспект показує, як дров'яний випал перетворився з утилітарного процесу у важливий художній

інструмент. Ключовою особливістю дров'яного випалу є використання спеціальних печей, призначених для підтримки високої температури протягом тривалого часу. Дослідження різних видів дров'яних печей перехресного потоку розкрило їх технічні особливості та вплив на кінцевий результат. Встановлено, що процес випалу залежить від багатьох факторів, включаючи тип деревини, атмосферу печі, температуру та тривалість випалу. Ці параметри формують неповторний характер кожного виробу. Використання дров'яного випалу в художніх цілях дозволяє досягти неповторних візуальних ефектів, таких як натуральна зольна полива, текстуровані поверхні, природні колірні переходи. Дров'яний випал є унікальним процесом, який об'єднує традиції та інновації, технології та мистецтво. Його значення полягає у здатності створювати об'єкти, які не лише вражають візуально, але й несуть глибокий емоційний зміст. Ця техніка вимагає майстерності, терпіння та розуміння матеріалу, а також готовності працювати зі стихією вогню, який стає повноправним співавтором. Проведене дослідження не лише поглибило знання про дров'яний випал, але й показало його безмежні можливості для творчого самовираження. Дослідження демонструє, що ця техніка залишається актуальною й надихаючою для сучасних митців, пропонуючи нескінченні можливості для відкриттів у галузі художньої кераміки. Технологія дров'яного випалу в печах перехресного потоку продовжує розвиватися, і її можливості відкривають нові горизонти для сучасного керамічного мистецтва. Дров'яний випал - це не лише технологія, а й філософія. Він відображає взаємодію людини з природою та вогнем, дозволяючи створювати унікальні керамічні вироби, які неможливо повторити. Саме в цьому полягає його цінність і незгасаюча актуальність у світі керамічного мистецтва.

**Ключові слова:** історія мистецтва; історія культури; історія кераміки; глина; художня кераміка; печі для дров'яного випалу кераміки

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