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Case report

Ancient ceramics kilns of the *mantou* type in the Russian Far East

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ABSTRACT

The remains of ceramics firing structures unique for the archaeological record of the southern Russian Far East were excavated in 1994 at the Sergeevka site in the southeastern Russian Maritime Province. Evidence for using these kilns for tile production was revealed. The remains are dated to the Jurchen period (12–13th century) of the Medieval epoch when the research area was, first, the northeastern periphery of Jin Empire and later, part of the Dong Xia state. Recently, a re-examination of archaeological materials from Sergeevka kilns site was carried out. The kilns are interpreted as *mantou* type firing structures. At present this site is the northeastern outpost in the East Asian distribution area of *mantou* kilns. Based on data from examination of samples of ceramics from the Sergeevka site, the technical potential of the kilns, in particular temperature regime, was inferior to that of *mantou* kilns used in ceramic production in Northern China since the Tang period.

1. Introduction

According to archaeological and historical evidence two basic advanced firing technical devices were used for the production of ceramics and porcelains in ancient China - the *long*, or dragon, kiln, first invented in the middle–second half of the 1st millennium BC somewhere in the Yangtze basin of southern China, and the *mantou* type kilns most widespread in various regions of northern China since the Tang dynasty period, or after the middle of the 1st millennium AD. Both were built of bricks and intended to achieve stable firing temperatures up to 1200–1350 °C. The construction principles of the *long* and *mantou* kilns were adopted by potters of surrounding regions of East Asia, Central Asia and South-East Asia (Barnes, 2001: 92–116; Kerr and Wood, 2004: 314–334, 347–364; Hein, 2008; Pohl et al., 2012; Lee, 2015).

Specific external features of the *mantou* kiln type were the strongly convex dome resting on relatively high walls, the contour of which caused the kiln to be named after a traditional Chinese steamed bun, or "*mantou*", and often a "horse-shoe" - like horizontal plan, with the widest part of the floor at the front, and the narrow part at the back. The kiln's firebox was located below the floor level at the front of the firing chamber. The floor area of the firing chamber was up to 10 m^2 or above in size. At the floor level on the back wall were located flue exits connected to a brick chimney tube, or pair of them, located behind the back wall. In particular, this kind of kiln often had six flue exits located symmetrically along the back wall. Each unit of three flue exits was joined to a separate chimney tube (Barnes, 2001: 103–104; Kerr and Wood, 2004: 314–334).

In ancient China *mantou* type kilns were used for firing various kinds of ceramics—architectural ceramics, stoneware, and porcelain wares. Firing temperatures ranged in the interval 1000–1350 °C. *Mantou* kilns operated in oxidizing and reducing atmospheric regimes. Since the 10th century in northern China coal has been used as the main fuel for *mantou* kilns. Clusters of *mantou* kilns were usually located near extensive coal deposits (Kerr and Wood, 2004: 297–301).

The subject of this article is archaeological evidence for *mantou* type ceramic kilns on the mainland of the southern Russian Far East during the Jurchen period of the Medieval epoch. The research area is the Russian Maritime Province bordering northeast China and the Korean peninsula (Fig. 1). In this article the term "Jurchen period" indicates the period of the 12–13th centuries. This period corresponds mainly to the temporal frames of the Jin dynasty, 1115–1234. According to historical, archaeological, and epigraphic records, in 1115–1215 the subject area was part of the northeastern periphery of the Jin Empire founded by Jurchen tribes. The borders of the Jin Empire embraced the territory of Manchuria, northeast China, the most northern area of the Korean peninsula, and the territory of the modern Russian Maritime Province. The political and administrative systems of the Jin Empire imitated ones of the Chinese Empires. In particular, the state's territory was divided into 19 governorates. The governorate of Shuibin was located in the territory of the Russian Maritime Province. In 1215 three northeastern neighboring governorates - Helan, Huligai and Shuibin – separated from the central Jin powers and established an independent Jurchen state named Dong Xia which existed until 1233. In 1233–1234 the Mongols crushed and conquered the Jin Empire and Dong Xia state,

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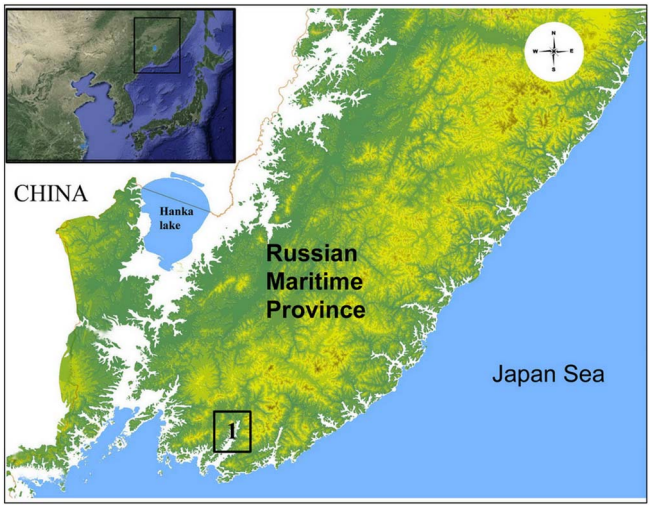

Fig. 1. Russian Maritime Province with research area location (1).

and sometime later the area under consideration fell into the hands of Yuan Dynasty authorities. The Jurchen population occupied this territory at least until the end of 13th–early 14th century (Artemieva and Ivliev, 2000; Ivliev, 2010).

Many archaeological sites belonging to the Jurchen period have been discovered in the research area. They are mostly walled towns and fortified settlements located on river plains and in mountainous areas. A series of sites has been studied under wide-scale excavations – the Shaiga walled town, Nikolaevka walled town, Anan'evka walled town, Lazovskoe walled town, Krasny Yar walled town, and others. The remains of high-status courtyards, column-type buildings, metalworking workshops, and commoners' houses were excavated. In a few cases the remains of isolated architectural complexes located outside the walled towns have been unearthed. Preliminarily they were recognized as temples of a Buddhist cult. The characteristics of Jurchen town planning, architecture, and building techniques were influenced greatly by Chinese cultural traditions. Artifact assemblages from Jurchen sites are rich in various kinds of metal tools, weaponry, ornaments made of bronze and semi-precious stones, household utensils, coins, imported glazed stoneware and porcelain wares (Artemieva and Usuki, 2010).

Two main groups of earthenware ceramic artifacts are present at Jurchen sites in the Russian Maritime Province. The first group is daily pottery made mostly on a potter's wheel: various vessels for the kitchen, storage, table service, and technical functions. Pottery is the most common artifact category at any walled town or fortress. Many pottery fragments and complete vessels are concentrated in ordinary houses and in areas with high status buildings and estates.

The second group consists of architectural ceramics, including roof tiles, bricks, and decorative sculptural objects. In excavated walled towns the concentrations of architectural ceramics are connected certainly with the areas of remains of high status column-type buildings (palaces, administration offices). Roof tile assemblages are characteristic also for isolated architectural complexes interpreted as temples.

The current state of investigations in pottery and architectural ceramics excavated at Jurchen sites in the Russian Maritime Province has some “white spots”, or gaps in our knowledge. In particular, an unknown subject is the system of ceramic production. Until now evidence for workshops or certain technological operations in pot-making or tile-making and brick-making were not recognized in the territories of walled towns and in close vicinity. No historic records mentioning the production of tiles or pottery are known. There also are no available data on raw materials sources for pottery and architectural ceramics production. Another relevant subject is the technique and technology used for firing ceramics.

Most of the ceramics of both groups are grey on the surface and the interior as revealed from fractures. This feature may be interpreted as the result of firing in special kiln structures under a reducing atmospheric regime. According to data from preliminary investigations, firing temperatures of the ceramics from the Russian Maritime Province's Jurchen sites are thought to fall mainly within the interval 900–1000 °C, though sometimes above 1000 °C (Zhushchikhovskaya and Nikitin, 2014). One of the most interesting and little known research subjects is the construction pattern and technical potential of firing devices used in ceramic production during the Jurchen period in the Russian Maritime Province territory.

At present, a single reliable case of remains of a ceramic kiln for firing, attributed to the Jurchen period, is known for the southern Russian Maritime Province. This is the Sergeevka kiln site, where firing structures of the *mantou* type were excavated. These materials are presented below. The objective of this article is to evaluate the structural and technical characteristics of the discovered kilns and to suggest a cultural-historical interpretation of these data.

2. Materials and methods

The archaeological remains considered in this article are chiefly the remains from the Sergeevka site's kiln structures and samples of ceramic production associated with these kilns.

The remains of kilns built of bricks were discovered and excavated by Dr. Yuri M. Vasil'ev on the southeastern outskirts of the modern village of Sergeevka in 1994 (Vasil'ev, 1998, 2009). Archaeological field work at the kiln's location revealed substantial disturbance of cultural layers by the construction of modern houses, farmsteads, and farming activities of the villagers. In this situation wide-scale excavations at the site were impossible. Between 1994 and 2015 no archaeological work was conducted at the Sergeevka kiln site. In 2015 and 2016 the authors conducted field surveys at the site and its surroundings. The characteristics of the archaeological record of the Sergeevka site presented in this article are based on the results of the initial field work and the most recent data.

The archaeological evidence at the Sergeevka site is concentrated mainly on the left bank terrace of Semenov Klyuch Creek, a tributary of the Partizanskaya River. The latter is one of largest rivers in the Russian Maritime Province, and its valley is rich in Jurchen period archaeological sites. Among them are the large walled towns of Shaiga and Nikolaevka, where extensive assemblages of pottery and architectural ceramics were unearthed (Artemieva and Usuki, 2010: 58–66). The Sergeevka site is located 7.0–8.0 km from the Shaiga walled town, and about 28 km from the Nikolaevka walled town (Fig. 2).

The left-bank terrace of Semenov Klyuch Creek, formed of clay

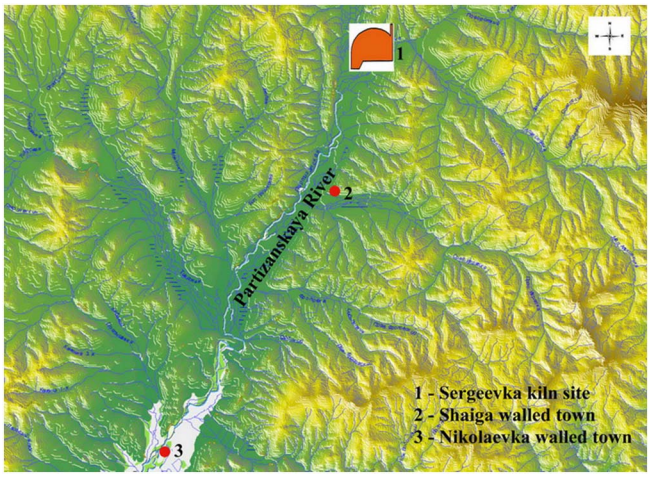

Fig. 2. Partizanskaya River valley area. 1 – Sergeevka kiln site. 2 – Shaiga walled town site. 3 – Nikolaevka walled town site.

loam, is 1.5–2.0 m high. The terrace surface is almost level. Most of this area is occupied by the farmsteads of modern villagers, private kitchen gardens and wooden buildings. The process of destruction and collapse of the terrace edge occur continually. Archaeological remains and artifacts are found over an area about 1200 m^2 on the terrace surface and in the bank's face for a distance of about 50 m along a stream. During the field work of 1994 the remains of three kiln structures were recognized (Fig. 3). The remains of kiln N2 were located quite close to the terrace edge. The remains of kiln N1 were unearthed at a distance about 6.0 m southeast of kiln N2 and about 7.0 m from the bank's edge. The remains of another kiln structure (N3) were recognized at a distance about 5.0 m south of kiln N2. All kiln structures were damaged and partially destroyed. It is interesting to note that on the surface of the terrace, several meters east of the remains of kiln 1, were many small fragments of fragile, non-fired tiles in a humus layer. These were found during excavations in 1994.

The kiln structures N1 and N2 were studied through the excavations. Kiln N1 was filled with fired roof tiles. Based on the morphological features of the tiles, the kiln structures were presumed to belong to the Dong Xia stage of the Jurchen period. According to preliminary conclusions, the Sergeevka site was the location of a tile-making workshop. The unearthed structures were determined to be tile firing kilns. However, there is no explanation of their construction type and technical potential within the context of East Asian ceramics kiln history (Vasil'ev, 1998, 2009). The authors recently undertook a re-examination of the data from the 1994 field work to determine the general construction type of the unearthed kilns.

Special research was focused on the two main kinds of ceramic artifacts discovered at the Sergeevka site. The first is roof tiles represented by whole samples from kiln N1 and samples that are mostly fragmented and damaged that were collected over the area of the kilns. We consider this kind of ceramics as production from kilns containing information about the atmospheric and temperature regimes of the firing process. Another kind of ceramic artifact from the Sergeevka site—the bricks used for constructing kiln walls—are also of some interest for the characteristics of the kiln working regime, since they were directly influenced by the temperature and atmospheric conditions during firing.

Some special methods were applied to the examination of ceramics samples. These methods were used for determination of the physical properties of the ceramic body brought about by the firing process, in particular, the temperature regime. Water absorption (WA) testing to determine the relative porosity of the ceramics body was executed by estimating the weight increase (in %) of a water-saturated ceramic sample in comparison to a dry sample. In general, lower WA indexes correspond to lower porosity, and, consequently, higher density and lower water permeability of ceramic body, indicating a more advanced firing temperature regime. The degree of porosity of ceramic body is the result of structural transformations during the firing process. For the interval of firing temperatures 800–1050 °C in ordinary potter's clays, the processes of sintering and vitrification of the clay matrix develop gradually causing significant decreasing of porosity. The WA indexes ≤ 5–7% correspond to a low-porous, very dense ceramic body. The interval 7–14% corresponds to a moderately porous, relatively dense ceramic body. The indexes ≥ 15% indicate high-porous friable ceramics with high water permeability (Avgustinik, 1975: 221–224, 296, 347–355; Shepard, 1985: 125–130; Rice, 1987: 350–354).

Surface hardness testing by the Mohs scale is another method available for obtaining data to assess the quality of fired ceramics. Hardness indexes are of relative value, indicating the degree of ceramic density and strength caused by firing (Shepard, 1985: 113–116; Rice, 1987: 354–357). SEM/X-ray analysis (scanning electron microscopy and X-ray spectroscopy)[1] detects structural transformations in ceramic matter resulting from firing temperatures. In particular, the most important indicator is the degree of clay matrix vitrification (Tite et al., 1982; Bjork, 1995: 52–61; Maniatis, 2009).

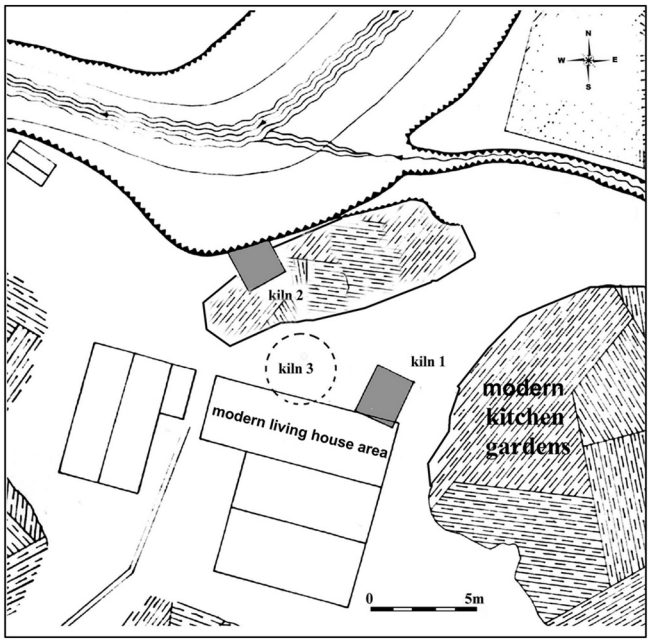

Fig. 3. Sergeevka kilns site area.

3. Research results

This section of the article considers the structural features of the unearthed kilns, and the results of examination of the ceramics samples discovered (tiles and bricks) in relation to the technical characteristics of the kilns.

3.1. Kiln construction

3.1.1. Kiln N1

The structure of this kiln was better preserved than that of the kiln at N2. The remains of the firing chamber and traces of the damaged furnace chamber were unearthed. Initial traces of kiln construction were detected at a depth of 0.1–0.15 m beneath the modern surface—there were a few fragments of the firing chamber's damaged vault. The floor of the firing chamber was unearthed at a depth of 1.86 m beneath the surface.

The firing chamber had brick walls preserved to a height of 1.5 m. Two side walls and the back wall were unearthed (Fig. 4). The inner surfaces of bricks had a dark grey or blackish color, while the outer surfaces were yellowish or light orange. The firing chamber's horizontal floor was formed of very dense rammed earth. According to excavation data, the floor area was 1.97 m long and maximally 1.67 m wide. The horizontal plan of the firing chamber's floor looks like a trapezoidal with long, slightly convex sides. The side walls also had a slightly convex contour. At floor level in the back wall of the firing chamber four flue exits between bricks were unearthed. The exits were 0.08 m high and from 0.15 m to 0.23 m wide. Several rows of bricks standing edgewise were situated longitudinally on the floor (Fig. 5). The firing chamber of kiln N1 was completely loaded with roof tiles. There were 1840 standard tiles stacked compactly in four levels (Fig. 6). The lowest level of tiles rested above the floor on rows of bricks.

[1] SEM/X-ray analyses of ceramic samples were conducted in the Center of Electron Microscopy at the Institute of Marine Biology of Far Eastern Branch of Russian Academy of Sciences, Vladivostok.

Fig. 4. Sergeevka kilns site. Kiln N1. Preserved part of side brick wall. The photo from field report of Dr. Yu.M. Vasil'ev (1998).

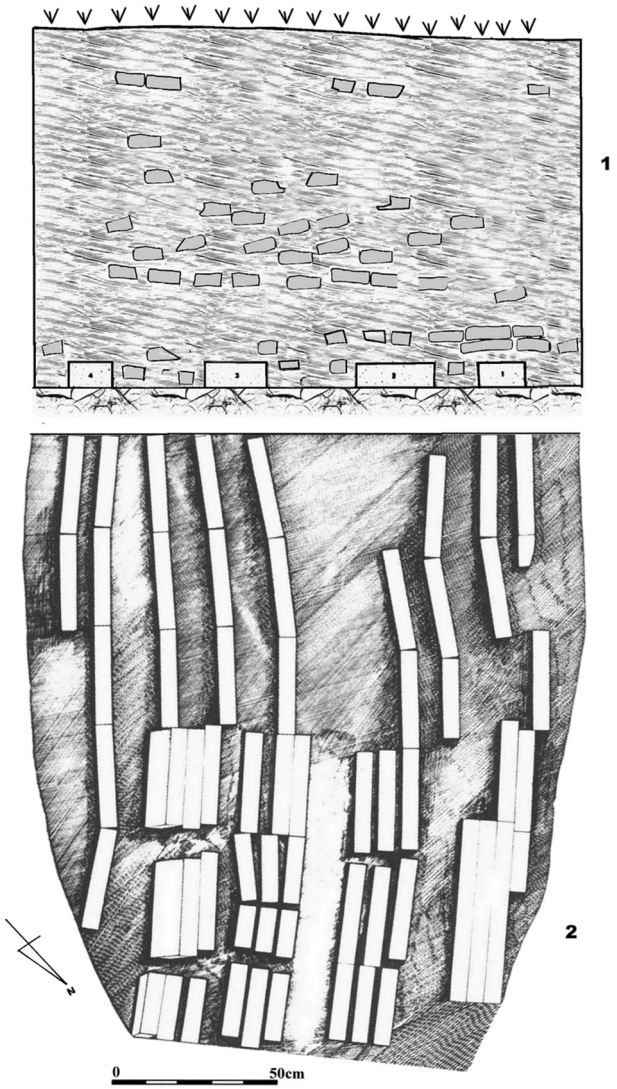

Fig. 5. Sergeevka kilns site. Kiln N1. Horizontal plan of firing chamber's floor (II) and preserved part of back wall (I).

Fig. 6. Sergeevka kilns site. Kiln N1. The tiles inside the firing chamber. The photo from field report of Dr. Yu.M. Vasil'ev (1998).

The kiln was oriented with its firebox toward the stream. The firebox was almost totally destroyed. The floor at the front of the firing chamber could be traced descending abruptly and steeply downward. It was obvious that the firebox was located below the floor level of the firing chamber. A few small pieces of charcoal were found in the area of the destroyed furnace chamber. The firing chamber's superstructure was also destroyed. An accumulation of fragments of burnt clay, tiles, and bricks was unearthed at the level of the upper part of the firing chamber's walls. These were undoubtedly the remains of the kiln's superstructure.

3.1.2. Kiln N2

This kiln structure is represented by a partially preserved floor area and the brick side walls of the firing chamber. The horizontal plan of the floor had a trapezoidal contour with long, slightly convex sides similar to the floor of kiln N1. The maximal width of the floor was 2.24 m. The revealed length was 2.42 m. The floor was covered by a layer of dense burnt clay. The remains of longitudinal rows of bricks under the floor in the front part of firing chamber were unearthed. The back wall of the firing chamber was preserved at its lower part where six flue exits 18–20 cm high and 16–18 cm wide were detected (Fig. 7). Some exits were partially filled with brick fragments and pieces of burnt clay.

3.2. Results from examination of the ceramics

3.2.1. Tiles

The tiles from the Sergeevka site are two of the most common kinds of tiles found at Jurchen walled towns in the Russian Maritime Province. The first kind is represented by simple undecorated tiles with a slightly curved arc-like profile. A large assemblage of about 2000 standard tiles was recovered from the firing chamber of kiln N1. The tiles are 30–31.5 cm long and 20–21 cm in maximal width (Fig. 8-1). Some samples of a second kind of tile were found in the area of the Sergeevka site. These tiles similar in shape and size to the first kind are decorated with finger-stamped roundish and oval-like impressions along one curved edge (Fig. 8-2). At Jurchen sites there are tiles with other kinds of decoration – mostly, simple stamped patterns along one edge. Usually, roof tile assemblages corresponding to the remains of certain column-like buildings include both kinds of tiles. Obviously, ornamented tiles were produced for placement along roof edges for decoration according to a long-held Chinese architectural tradition. There had not been any documented case of finding glazed tiles at Jurchen sites in the Russian Maritime Province until now.

The color parameters of the tiles indicate two atmospheric firing regimes— oxidizing and reducing. The tiles from the N1 kiln vary in their surface and fracture color, from yellowish to orange tones caused

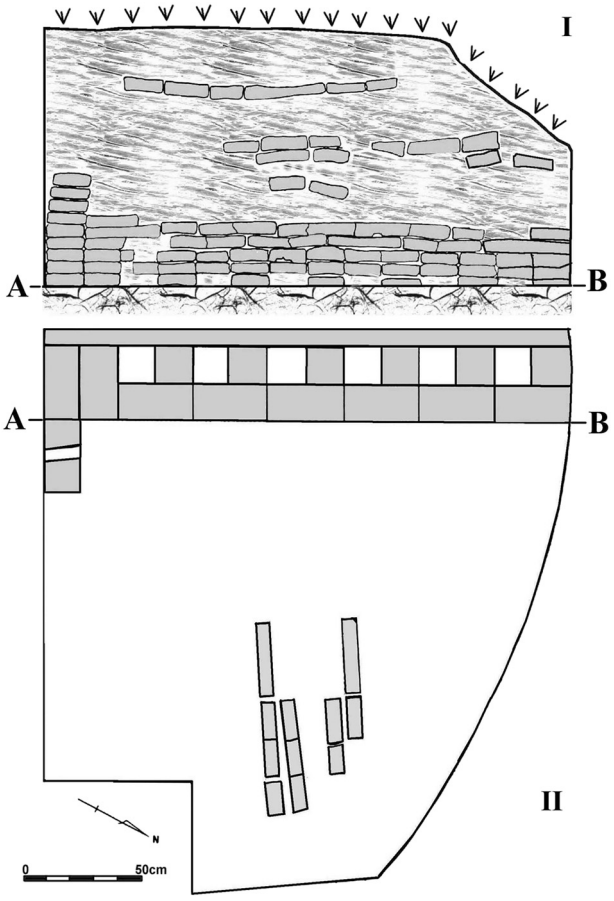

Fig. 7. Sergeevka kilns site. Kiln N2. Horizontal plan of firing chamber's floor (II) and preserved part of back wall (I).

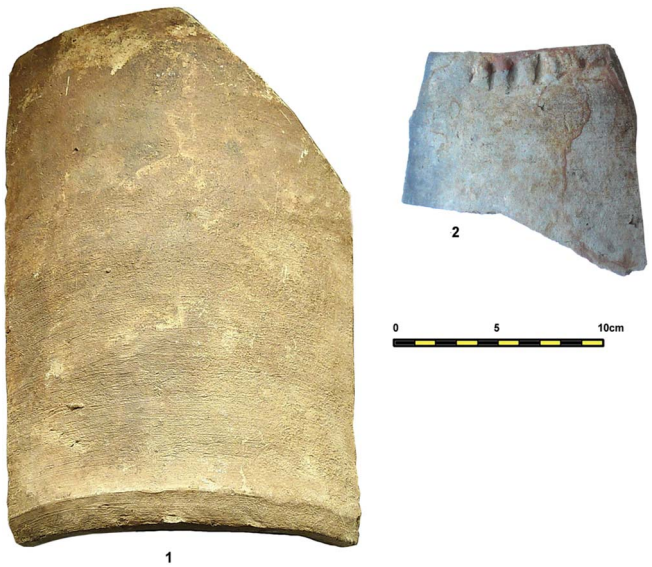

Fig. 8. Sergeevka kilns site. The tiles samples. 1 – undecorated plain tile. 2 – the fragment of decorated tile.

by the oxidizing of ferric compounds in the clay during firing in an oxygen saturated atmosphere. Most of the tiles collected in the site area of the kilns have a grey color on the surface and in the interior. The tones vary from dirty grey to bluish grey. This indicates that the firing was under special atmospheric conditions, causing reduction of ferric compounds (Shepard, 1985: 19–24, 213–223). There are many deformed or slightly warped samples caused by the effects of firing among the grey tiles. Some samples have traces of surface melting.

Table 1
Water absorption index of tiles samples from Sergeevka kilns site.

Firing conditions	Amount of samples	Water absorption index	
		Indexes range	Average index
Reducing	18	0.7–19.0%	5.5%
Oxidizing	13	10.4–19.1%	14.1%

The index of testing water absorption (WA) for the samples and the Mohs scale of surface hardness show that tiles fired in different regimes differ in quality of the ceramic body. Our data indicate that reduction-fired tiles have a tendency toward lower WA indexes (Table 1). It has to be noted that the lowest values of WA index 0.7–1.9% are determined for samples with obvious traces of firing deformation and surface melting.

The surface hardness values for grey, reduction-fired samples vary within the limits 5.0–8.0, and for oxidizing-fired samples, around 4.0.

SEM examination of fresh fractures on 14 tile samples revealed different ceramic microstructures caused by different degrees of clay matrix vitrification under firing conditions. The interpretation of the obtained results and estimation of approximate firing temperatures under reducing and oxidizing regimes were executed according to methods and principles of SEM for examination of archaeological ceramics (Tite et al., 1982; Bjork 1995:52–61; Maniatis, 2009).

A microstructure with continuously, or highly, vitrified clay matrix is detected for four reducing-fired samples with WA indexes of 0.7–2.7%. (Fig. 9-1). The pattern of continuous vitrification is indicated by the presence of roundish bloats over the solid substance. This microstructure corresponds to firing temperatures approximately up to 1000 °C or somewhat above for low refractory clays under a reducing atmosphere. Three of the samples examined have external traces of slight firing deformation.

A microstructure with an extensively vitrified clay matrix is detected for 2 reducing-fired samples with WA indexes of 4.2% and 5.8% (Fig. 9-2). The estimated firing temperatures for low refractory clays under a reducing regime are around 900 °C or slightly above. A microstructure with an initially vitrified clay matrix is detected for one reduction-fired sample with a WA index of 11.0% (Fig. 9-3) and two oxidizing-fired samples with WA indexes of 10.7% and 14.2%. The pattern of initial vitrification is indicated by a dominating amorphous structure with the occurrence of local areas of cellular-like structure. The supposed firing temperatures are 800–850 °C or slightly above. A microstructure with an amorphous pattern without any evidence of vitrified clay matrix is detected for four samples of oxidizing-fired tiles from kiln N1 with WA indexes of 16.8–19.1% (Fig. 9-4). It is likely that the firing temperature was relatively low for the beginning of vitrification, approximately around 800 °C.

Therefore, the examination of tile samples revealed evidence for variation in the quality of ceramic bodies caused by some differences in firing conditions, especially from the temperature regime. This subject will be discussed further below.

3.2.2. Bricks

The bricks of which kilns N1 and 2 were built were of a relatively standard size: 30–32 × 15–16 × 5–6 cm. The above-noted color differences between the inner and outer surfaces of the brick walls of kiln N1 indicate different atmospheric conditions during firing cycles. The inner surfaces of the firing chamber's dark grey walls were probably exposed to a carbon-saturated reducing atmosphere. The yellowish and light orange outer surfaces were oxidized in open air. No traces of melting activated from long term impact of high temperatures were detected on the inner surfaces of the brick walls of kiln N1 and kiln N2.

Fragmented bricks were collected over the site area including the

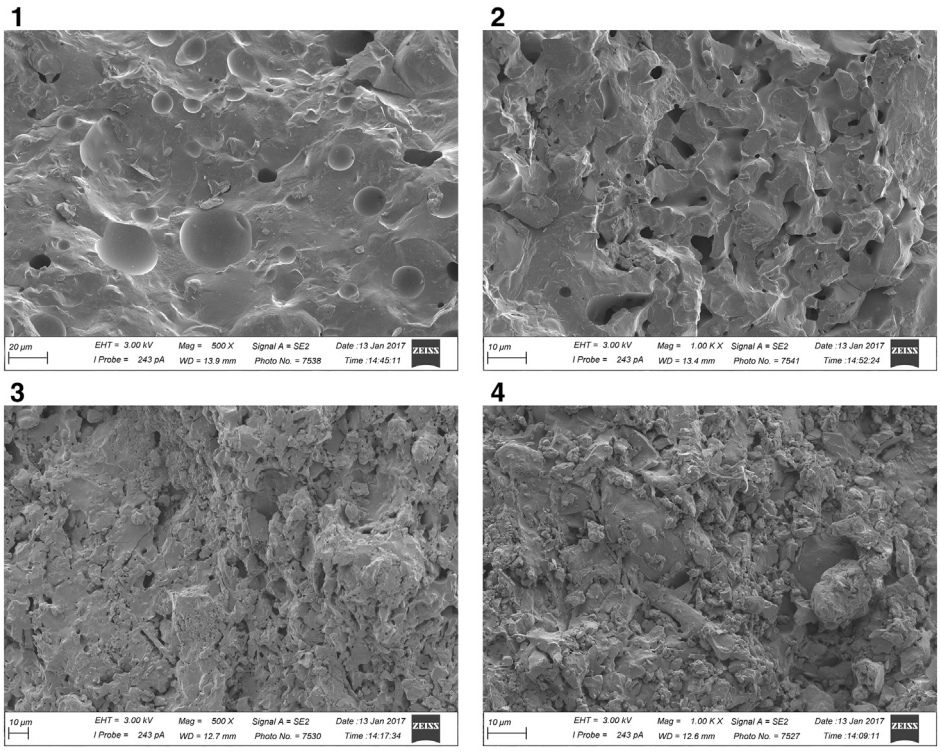

Fig. 9. Sergeevka kilns site. Electronic micrographs of ceramics body in tiles fractures. Different degrees of clay matrix vitrification: 1 – high (continuous) vitrification, 2 – extensive vitrification, 3 – initial vitrification, 4 – no vitrification.

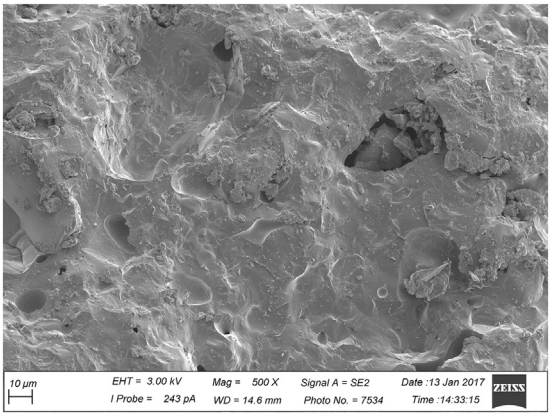

Fig. 10. Sergeevka kilns site. Electronic micrographs of ceramics body in brick fracture. Transition stage between extensive and continuous vitrification.

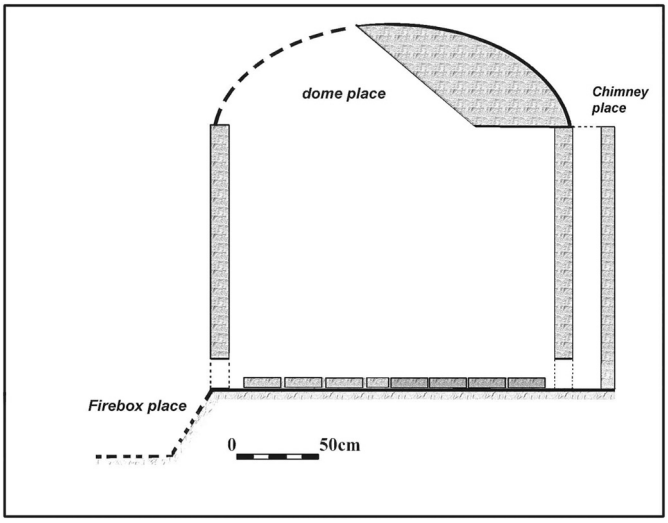

Fig. 11. Sergeevka kiln site. Hypothetical model of Sergeevka kilns of *mantou* type (profile view).

kiln. Some samples have a fragile and “soft” ceramic body, others are dense and hard. Most of the collected samples are of a dirty grey and blackish color. Three samples were examined by WA testing. Two samples have low indexes (3.5% and 4.7%), and one sample has a high index 22.3%. The last case indicates a porous, weekly fired ceramic body. SEM analysis of the brick sample with a WA index of 3.5% revealed a microstructure indicating the transition stage between an extensively and continuously vitrified clay matrix (Fig. 10).

4. Discussion and conclusion

The excavated remains of two kilns at the Sergeevka site reveal certain structural features: 1)—a single firing chamber; 2)—a trapezoidal floor in horizontal plan with long, slightly convex sides, 3)—the use of bricks for construction of kiln walls, 4)—a row of flue exits at floor level in the back wall, and 5)—the disposition of the firebox at the front of the firing chamber, below the floor level. These features are very similar to the basic characteristics of the *mantou* type kiln exploited in ceramics and porcelain production in northern China since the middle of 1st millennium AD (Barnes, 2001: 103–104; Kerr and Wood, 2004: 320–324).

The fragmentary preservation of kiln remains at the Sergeevka site does not allow tracing the fireboxes, chimneys, or superstructures. We can reconstruct these features based on a hypothetical model of the Sergeevka kilns (Fig. 11). The kilns likely had two chimneys, judging from our observations of the flue outlets. In both cases, the number of flue exits—four and six—located symmetrically along the floor level of back wall were detected.

An important detail identified for both kilns is the longitudinal rows of bricks over the floor of the firing chamber. These rows served as supports for the lower level of tiles loaded into the firing chamber. The brick rows also filled the role of flue channels for air circulation under the floor, creating more even firing of the tiles. The firing chambers of both kilns had floor areas of about 4.0 m^2. This size was substantially

less than the sizes of northern China *mantou* kilns of the Song and Jin periods.

Because of destruction of the cultural layers at the Sergeevka kiln site we have at present only fragmentary evidence of the original assemblage of firing kilns. It seems likely that the site presents a tile-making complex consisting of firing kilns and other objects in the production process. This idea is supported, first, by the above-noted find of unfired tile fragments near kiln N1. It is probably evidence of the place where the drying process occurred. Second, the area of Sergeevka village and its surroundings are rich in clay deposits. For instance, at a distance of about 2.0 km from the kiln site there is a source of good quality low refractory clay that is easily available for mining. The deposits contain lenses of yellowish clay and light grey clay. Both are highly plastic and homogeneous. Modern local villagers use this source for various home needs. The availability of clay raw material can be considered an important factor in the development of local ceramics production.

To support the idea of a tile-making complex at the Sergeevka site, one has to emphasize the availability of coal fuel resources. This area of the Partizanskaya River valley is rich in coal deposits (Zonn et al., 2016: 115). In particular, these deposits are known in the vicinity of Sergeevka village, a distance of 3.0–5.0 km from the Sergeevka kiln site (Anert, 1928).

In ancient China ceramic production complexes included not only the firing kilns but also placed nearby the workshops, working places, and sometimes the houses of the potters. The whole cycle of technological operations, beginning from ceramic paste preparation and finishing by the firing, was carried out in such complexes usually located near sources of raw clay. In particular, this pattern of labor organization is documented for various regions of China during the Tang, Song, Ming and Qing dynasties (Guo, 2000; Kerr and Wood, 2004: 428–432, 439–443).

A special question concerns the atmospheric and firing temperature regimes in the Sergeevka kilns. It may be supposed that the firing process in the kilns included two stages—the initial one in an oxidizing regime and followed by one in a reducing regime. The tiles from any Jurchen site in the Russian Maritime Province are mostly a grey color, but not always. This pattern often indicates that a reducing firing was practiced. The case that kiln N1 was filled with oxidizing-fired tiles may be interpreted as evidence of a firing process that was not completed. The reducing stage of the firing was not carried out for some reason. The tiles from kiln N1 are inferior to grey reducing-fired tiles in the quality of the ceramics body according to noted above results of water absorption testing, surface hardness testing and SEM examination.

In is known that old Chinese architectural ceramics were traditionally fired under a reducing regime, which produced the grey color of tiles and bricks. A reducing atmosphere may be provided inside the firing chamber in different technological ways. One of the most common ways known in Chinese ceramics-making from very early times was the “air starved fuel” reduction method. After the initial stage of the firing process under an oxidizing regime, the kiln's air draft was covered, which saturated the firing chamber atmosphere with the grey smoke of unburned fuel, combining carbon monoxide (CO) and carbon dioxide (CO_2). This resulted in the appearance of the grey color of the surface and fracture of the fired ceramic product (Kerr and Wood, 2004: 297–300).

The results noted above for the examination of tile samples by SEM, water absorption (WA) testing, and surface hardness testing are useful for judging the likely firing temperature regime for the Sergeevka kilns. According to our research data, the firing temperatures ranged in the interval from under 800 °C to 1000 °C, or somewhat above. The samples with highly vitrified ceramic bodies and very low WA indexes (0.7–1.9%) corresponding to high temperatures of firing are characterized mostly by external traces of firing damage. Therefore, it seems likely that high temperatures were not regular ones in the considered kilns. The absence of any melting on the inner surfaces of the brick walls of the firing chambers and only a little melting on surfaces of some bricks collected in kiln areas confirm that working temperatures were not permanently high. Moderate temperatures around 850–950 °C under a reducing atmospheric regime seem to have been more regularly conducted in the Sergeevka kilns. Such firing conditions provide earthenware ceramics of quite sufficient quality. Taking into account the presence of samples with a relatively high WA index, > 19.0% (Table 1) one can think that sometimes the firing temperatures and soaking time were not enough for the production of such good quality tiles. Notably, the assemblages of tiles from Jurchen sites in the research area usually contain specimens of different qualities – conveniently referred to as “hard” and “soft”. In particular, both kinds of tiles might have been used for the same kind of building construction.

It is important to emphasize that at the present time, the Sergeevka kiln site is the first documented evidence not only for the production of tiles, but also for ceramic production as a whole in the territory of the Russian Maritime Province during the Jin period. We conclude from our investigation of the Sergeevka kilns that there certainly was specialization of production for tiles—and it is likely for brick-making as well. No traces of pottery production and firing in these kilns were detected. However, we cannot exclude the possibility that these kilns might have been used for daily pottery firing, too. Based on the results of an examination of grey-colored, reducing-fired pottery, the average WA indexes are 11.5–13.2%, indicating a moderate quality of ceramic body and with high firing temperatures that were not high, that is, below 1000 °C. There are only rare cases of samples with relatively low WA indexes 6.3–10.0%, corresponding to a probable temperature of up to 950–1000 °C. Some samples from this group that were examined by SEM showed an extensively vitrified clay matrix. The common index of surface hardness is around 5.0–5.5, in some cases up to 6.0–7.0. So, we can suppose the same or very similar firing conditions for tile-making and ordinary pottery-making during the Jurchen period in the research area.

In northern China *mantou* type kilns were purposed for the firing of different kinds of ceramic production at different temperature regimes. During the Tang – Jin dynasties period architectural ceramics were fired around 1000 °C in a reducing atmosphere while firing temperatures for stoneware and porcelains production were up to 1200–1250 °C and 1300–1350 °C, correspondingly (Kerr and Wood, 2004: 297–298, 541–545). Tiles and bricks might be fired simultaneously, in the same kilns because the same firing temperature and atmosphere regimes were required (Guo, 2000).

Obviously, the technical capacities of the Jurchen period's *mantou* kilns at the territory of Russian Maritime Province were more restricted in comparison with Chinese *mantou* kilns. As judged by the results of our investigations the temperatures interval 850–950 °C was most common for firing tiles. There is no evidence of local production of stoneware and porcelains in the considered area. All unearthed specimens of these two types of ceramics are interpreted as certainly to have been imported from China. So, it seems unlikely that future research in the Russian Maritime Province will reveal the remains of high-temperature *mantou* kilns. However one can expect new findings of firing constructions close to the Sergeevka kilns with respect to technical potential and indication of tile- and pottery production. We estimate that the region of the Partizanskaya river basin rich in coal deposits and sites of the Jin period will be important for further discoveries of remains of *mantou* firing kilns.

The construction principles of the firing kilns unearthed at the Sergeevka site differ substantially from the construction principles of ceramics kilns excavated at sites of the period of the Bohai state, 698–926, in the Russian Maritime Province. Bohai sites represent an earlier stage of the Medieval epoch. Firing kilns of that time were of the tunnel-like, sloped type going back probably to the “dragon”, or *long*, kilns of southern China (Zhushchikhovskaya and Nikitin, 2014, 2015).

The records of the Sergeevka site provide some opportunity for precise data on the area of distribution of *mantou* kilns in East Asia. R.

Kerr and N. Wood identified the northeastern outpost of this kiln construction type—the Hai-cheng site on the Liaodong Peninsula where *mantou* kilns functioned during the Tang, Liao and Jin periods (Kerr and Wood, 2004: 330). Firing kilns of the *mantou* type could obviously have appeared in the southern Russian Far East when this territory became a peripheral part of the Jin Empire, in 12th century, or even sometime later, during the period of the Dong Xia state, 1215–1233. *Mantou* kiln construction, common for northern China since the middle of the 1st millennium, spread to adjacent regions. At present, the Sergeevka site in the Russian Maritime Province may be considered the northeastern outpost of the *mantou* kiln area.

Conflict of interest

The authors of submitted article confirm that the research subject and archaeological records considered in the article are not in the field of conflict of scientific interests

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