Ceramic Firing Structures in Prehistoric and Ancient Societies of the Russian Far East

IRINA S. ZHUSHCHIKHOVSKAYA AND YURY G. NIKITIN

INTRODUCTION

Technological history is an important part of past culture-historical patterns in any region of the world. The archaeological record allows researchers to obtain fragmented information about some old technologies, including the knowledge and skills possessed by ancient people in thermal processing of such raw materials as metallic ores and clays (Wertime and Wertime 1982). In particular, investigations of early pottery making and the craft of roof tile production focus significant attention on indicators of firing technology.

Pottery firing technologies have a long and prominent history in East Asia. The archaeological and historical records of China indicate dramatic technological developments, from ancient firing structures and kilns to the more elaborate high-temperature *long* ("dragon") and *manthou* ("steamed bun") kilns of historical periods that produced porcelain, stoneware, roof tiles, and other items until the twentieth century (Gerritsen 2012; Kerr and Wood 2004; Li 2009; Shangraw 1977). Further evidence of developments in ceramic-firing technology connected closely with the history of Chinese kilns has been found in the Korean Peninsula, Japanese archipelago, and neighboring regions of Southeast Asia (Barnes 1992; Choo et al. 2009; Hein 2008; Kato 2002; Koh Osgood 1952; Rha 2006; Shimada 2009).

This study summarizes data concerning firing structures in prehistoric and ancient societies of the southern Russian Far East region bordering the Korean Peninsula, northeast China, and the Japanese archipelago (Fig. 1). The initial steps of pottery-making technology in the mainland part of this region are dated to c. 13,000–12,000 B.C. (Derevyanko and Medvedev 1995; Zhushchikhovskaya 1997; Kuzmin, 2013). Sites from the Neolithic period onward have abundant earthenware remains, including fragmented and complete vessels. Cultural deposits associated with walled towns and settlements of the Early States epoch (the end of the seventh century to the thirteenth century) contain enormous amounts of ceramic wares made with potter's

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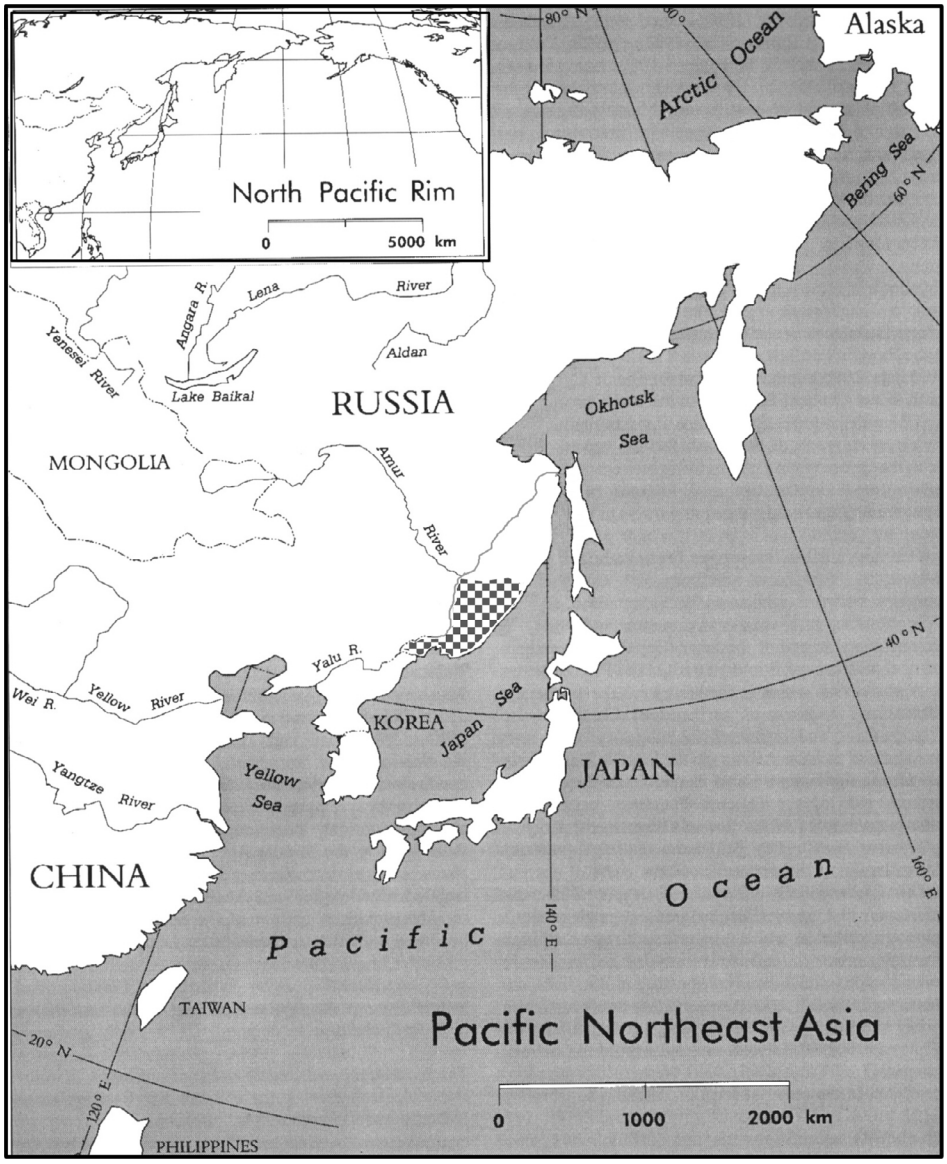


Fig. 1. Research area (checked pattern) in the context of Pacific Northeast Asia. Source base map Aikens and Rhee 1992.

wheels, as well as abundant roof tiles. In the course of archaeological fieldwork from the late 1960s to 2007, the remains of ceramic firing structures were discovered at several sites dated to the Prehistoric epoch, Pre-State period, and Early States epoch in the Russian Far East (Table 1). Almost all of these sites are located in Primor'e, which is the southernmost area of the Russian Far East (Fig. 2).

Table 1. Cultural and Chronological Systematization of Referenced Archaeological Records

EPOCH	PERIOD	CULTURE	CHRONOLOGY
Prehistory	Palaeometal period	Yankovskaya culture	10th/9th centuries B.C. to 3rd/2nd centuries B.C.
		Krounovskaya culture	4th century B.C. to 4th/5th centuries A.D.
	Pre-State period	Mohe culture	4th to 8th centuries A.D.
Early States epoch	Bohai State period		A.D. 698–926
	Jurchen Empire period		A.D. 1115–1234

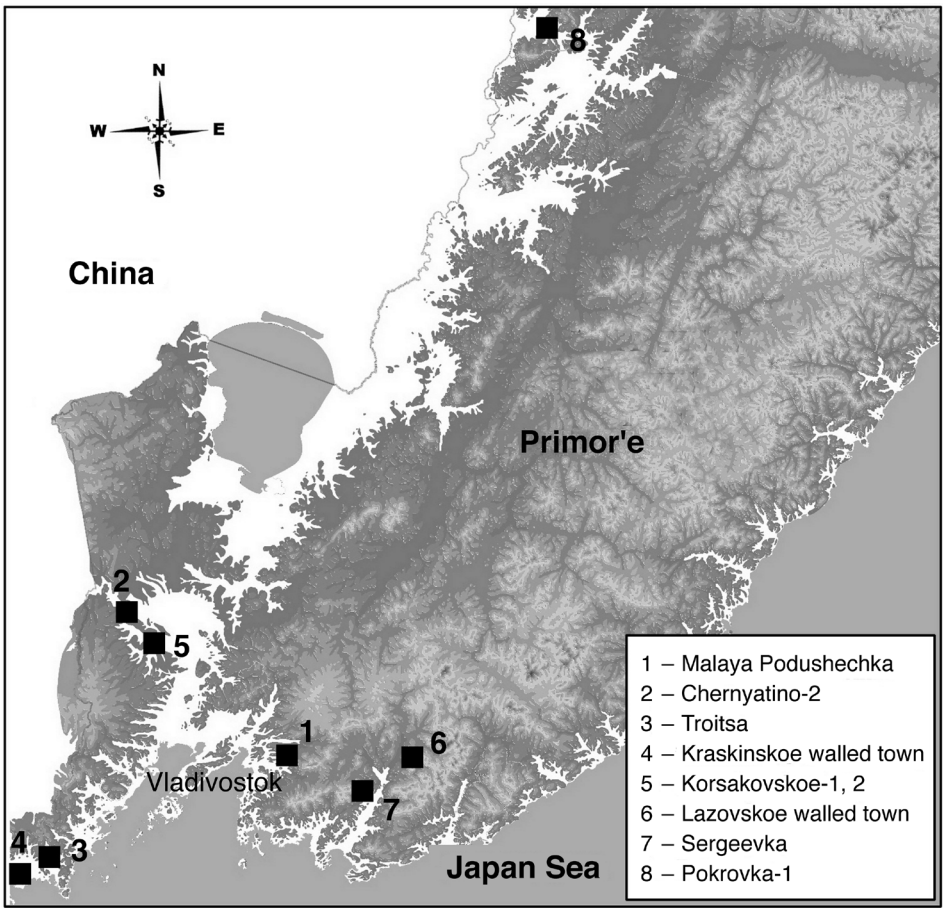


Fig. 2. Primor'e archaeological sites mentioned in the text.

PREHISTORIC FIRING STRUCTURES: THE ARCHAEOLOGICAL EVIDENCE

At present there is no unequivocal evidence (such as large burned areas and firing pits) of the simplest firing structures that might have been used for Neolithic pottery making. Analyses of ceramic samples from Neolithic sites show that, in most cases, average temperatures for pottery firing were 600–650 °C, which would correspond to open-air firing without kilns (Zhushchikhovskaya 2005 : 76–77). Recovered pottery samples from only a few late and final Neolithic sites (c. 2000–1000 B.C.) allow us to ascertain firing temperatures of up to 700–750 °C, suggestive of kiln use (Zhushchikhovskaya 2005 : 78).

The earliest remains of probable pottery firing structures are assigned to the Palaeometal period, c. 1000 B.C. to the fourth/fifth centuries A.D. During this period, the first bronze and iron metals appeared almost simultaneously in the mainland territories of the southern Russian Far East. The archaeological record suggests that the population of Primor'e and the Amur River valley not only used metal weaponry and tools, but also practiced some type of metal-working technology, in particular thermal processing of metals. The subsistence patterns associated with the communities of the Palaeometal period can be characterized as complex and varied, including gathering wild resources and food production. The use of earthenware of various shapes and functions was one of the most important attributes of everyday and ritual life (Zhushchikhovskaya 2005 : 88–94, 106–114).

Remains of likely pottery firing structures were discovered at sites associated with the Yankovskaya and Krounovskaya archaeological cultures. At present, the Yankovskaya culture is dated around the tenth/ninth centuries B.C. to the third/second centuries B.C., and the Krounovskaya culture to around the fourth century B.C. to the fourth/fifth centuries A.D. These cultures were not linked genetically, although both were involved in the broadly shared cultural patterns of Primor'e and the neighboring territories of Manchuria and the Korean Peninsula.

Firing Structure Remains at the Malaya Podushechka Site

Poorly preserved remains of several pottery firing structures attributed to the Yankovskaya culture were excavated in the late 1960s in southern Primor'e at the site of Malaya Podushechka, within its lower cultural horizon dated by radiocarbon to 2450 ± 50 years B.P. [MGU-499] (Andreeva et al. 1986 : 39–50, 190; Kuzmin et al. 2005) (Fig. 2). The remains presented as three separate accumulations of burned clay pieces with plant impressions resembling straw or reed stems on both the outer and inner surfaces. The accumulations were located within the ancient settlement area at a distance of 2–4 m from the pit dwellings. The distances between individual accumulations were 2.5–3 m. Horizontal plans of these accumulations revealed oval shapes. The areas of separate accumulations were 4 × 6 m, 4 × 2 m, and 4 × 3 m, while the thickness of burned clay accumulation layers was about 0.3–0.4 m.

A flattened surface covered with burned clay was discovered under one of the accumulations of burned clay. A layer of charcoal was traced under another accumulation. In a single case, a small piece of raw clay material was found near the burned clay accumulation. There is no reported evidence of ceramic waster samples in the areas of burned clay accumulation. All of the burned clay accumulations contained ceramic vessel assemblages, including from five to ten vessels in each. The largest accumula-

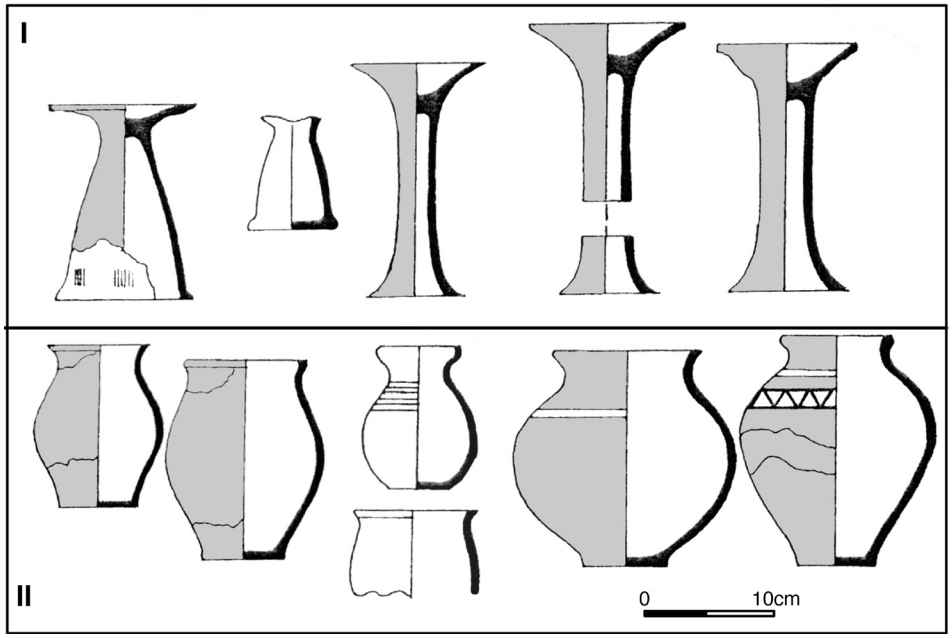


Fig. 3. Ceramic vessels derived from the accumulations of burned clay at the probable remains of firing structures. Vessel groups I and II correspond to separate assemblages. Malaya Podushechka site, Palaeometal period, Yankovskaya culture.

tion within the 4 × 6 m area contained two pottery assemblages located about 2 m apart (I and II in Fig. 3). Some vessels were nearly intact; others were restored from their fragments. Small- and medium-sized vessels, with a maximal height up to 35–38 cm, were distinguished. The vessels were of various shapes and functions, including pots, bowls, and footed bowls. The surfaces of all vessels were clear, without any use-wear traces.

The vessels from these clay accumulations had been fired in an oxidizing regime, at a temperature around 700–750 °C, according to the results of petrographic thin-section analysis and re-firing tests. Petrographic examination indicated that mineral fractions of the ceramic paste composition had no clearly visible traces of the phase or structural transformations that usually start above temperatures ranging from 800–850 °C (Zhushchikhovskaya and Zalishchak 1986). A re-firing test was executed under methodical conditions used in archaeological ceramics studies (Rice 1987: 427–428). The results suggested that the initial firing temperature was above 650 °C but did not exceed 750 °C. According to the Mohs scale, the hardness index of the pottery is around 3–3.5, further indicating low firing temperatures.

The burned clay accumulations excavated at Malaya Podushechka may be interpreted as the remains of pottery firing structures; this is further implied by the presence of pottery assemblages inside the accumulations. Traces of four structures were recorded, taking into account that the largest of these accumulations might correspond to two separate clay accumulation features. One can assume that firing structures were dome-like ovens built from a clay and straw mixture, probably on a framework made of some type of perishable plant material. It seems likely that the

ovens were small single-chambered structures, combining a fuel area or firebox with a pottery-firing area.

Firing-Structure Remains at the Chernyatino-2 Site

Fragmented remains of a simple-type pottery firing structure were excavated in 2007 at the site of Chernyatino-2 in western Primor'e (Nikitin and Jung 2008) (Fig. 2). The remains were unearthed from the lower horizon of the site, dated preliminarily to a late stage of the Krounovskaya culture, approximately the second to fifth centuries A.D. Kiln remains were located near a river bank within the area of this ancient settlement. An oval-shaped structure was excavated into clayey soil at 0.2 m depth. The oval depression was 2.3 m long and 1.9 m wide. The long axis of the depression was oriented southwest to northeast. The floor and preserved parts of the walls of the depression were burned and significantly hardened. The floor was covered by a thin ash layer that sloped slightly to the northeast border of the depression. It may be supposed that the oval structure combined firing and firebox sections, with the firebox section separated from the firing section by a low step. A semi-ring-shaped accumulation of burned clay pieces surrounded the depression. The thickness of the accumulation was about 0.2 m, with a maximal width of 1.2 m (Fig. 4). On the surfaces and inside the burned clay pieces were clear impressions of fixed plant materials. Impressions of grass or cut straw and surface impressions of wooden planks could be distinguished (Fig. 5: 1–3). It may be supposed that the domed part of the firing structure was built of clay mixed with grass or straw on a wooden framework.

The clay dome's walls were 5–6 cm thick. The kiln's firing chamber itself contained no direct evidence of any ceramic production. However, many pottery fragments were found in close proximity to the remains of the firing structure. Among these remains were some pottery waster samples with traces of over-firing, including cracks,

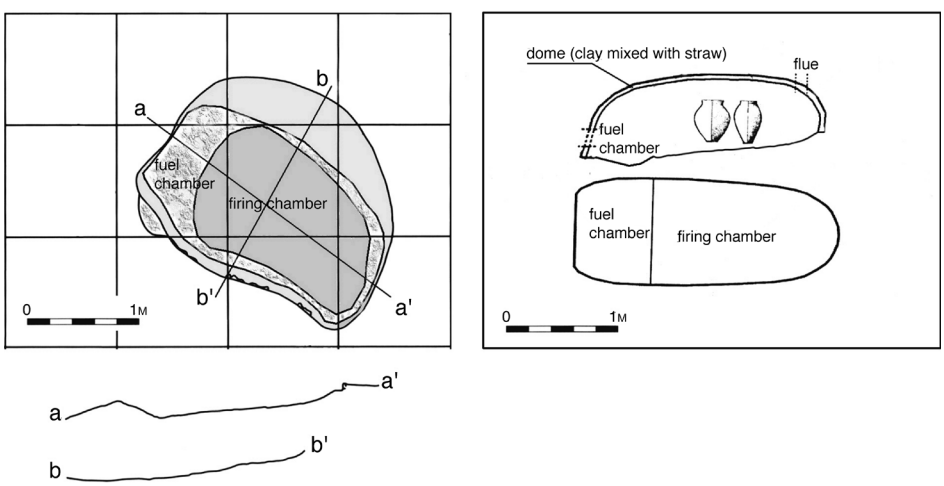


Fig. 4. Unearthed firing structure of simplest tunnel-like sloping cross-draught type: (left) horizontal plan (top) and profiles (bottom); (right) hypothetical reconstruction. Chernyatino-2 site, Palaeometal period, Krounovskaya culture.

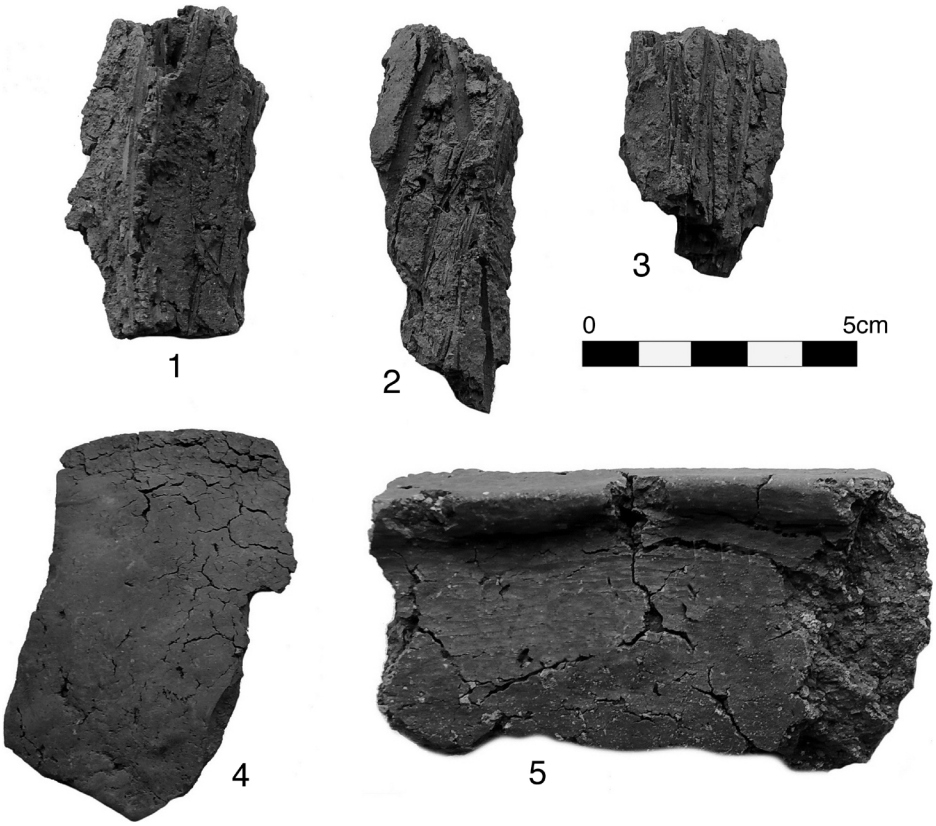


Fig. 5. Fragments of burned clay with plant impressions from remains of kiln dome (1–3); samples of firing spoilage pottery (4, 5). Chernyatino-2 site, Palaeometal period, Krounovskaya culture.

deformation, melting, and swelling of the surface (Fig. 5: 4, 5). Some indirect evidence indicates the probable technological level of the kiln at the Chernyatino-2 site. The pottery unearthed at the site belongs to the category of earthenware made of ferruginated fusible potter's clay typical of many places in the Primor'e region. One of the characteristics for detecting local pottery production quality is the index of average water absorption, with 10 percent correlating with a dense paste of medium porosity. The study of ceramic paste thin sections and the results of the re-firing test permit us to estimate approximate firing temperature at 750–850 °C, sometimes reaching perhaps 900 °C. According to this index, pottery waster samples suggest temperatures of more than 1000 °C. The potter's clays used in Primor'e usually start actively melting at around 1100 °C. Pottery with evenly blackened surfaces and cores occur frequently in this site. Pottery colors indicate a basic atmosphere regime, so oxidization was practiced in addition to smudging.

FIRING STRUCTURES OF THE PRE-STATE PERIOD: ARCHAEOLOGICAL EVIDENCE

The Pre-State period in the southern Russian Far East and neighboring territories of northeast China is represented by numerous archaeological sites of the Mohe cultural

tradition dated to the fourth to tenth centuries A.D. Mohe is also described in old Chinese historical chronicles. The Mohe community included several dozen separate ethnic groups, including members of the Tungus and Mongolian language families. Mohe tribes are considered to have been semi-nomadic peoples who traveled along the northern frontier of ancient imperial China and reached the Inner Mongolian steppes. The political structure of the Mohe tribes living in southern Manchuria provided the basis for establishing the first Far Eastern state of Bohai (A.D. 698–926). In the eighth century, the Mohe people of southern Primor'e were included in the Bohai State. A gradual process of incorporation of other Mohe tribes into the framework of statehood continued over the next three centuries (Ivliev 2005).

In general, Mohe archaeological assemblages are characterized by widespread use of iron weaponry and tools and the development of metal working, horse breeding, and other productive activities. Ceramic ware is the most common category of Mohe artifacts. The basic method of forming clay vessels was by hand, with a turntable used occasionally at the shape-finishing stage. The shapes and decorations of Mohe earthenware are diagnostically different from both earlier and later traditions.

The remains of two pottery firing kilns, designated as kiln N1 and kiln N2, were excavated in 1979 in the coastal area of southern Primor'e at Troitsa Bay (Andreeva and Zhushchikhovskaya 1986) (Fig. 2). The kilns were built on the bank of a stream running into the bay. Although the two kilns were only a short distance (3.5 m) from one another, kiln N2 was much better preserved than kiln N1, which was extensively damaged. Excavated remains indicate that the kilns belonged to the vertical up-draught type. The lower furnace chambers of both kilns had rounded contours and were depressed into sandy soil to a depth of 0.8 m. The red-colored sandy soil around the furnace chambers of both kilns was intensely burned. The bottom diameter of the furnace chamber of kiln N1 was about 1.5 m, while that of kiln N2 was about 1.2 m.

The walls of the kiln N2 furnace chamber were formed of granite rock slabs 0.2 m thick, coated with a dense clay layer. Both the clay coating and granite material showed strong evidence of long-term effects of high temperatures. The capacity of the furnace chamber for firing vessels was estimated at approximately 1 m^3. At the southern side of the furnace chamber was a 0.3 m wide break in the granite wall, possibly representing an entrance hole (Fig. 6).

The remains of the floor between the furnace and firing chamber were traced for kiln N2. The floor was comprised of a very dense burned clay layer, which integrated small flat pebbles. Fragments of the floor were better detected along the uppermost level of the furnace chamber. The area of floor was approximately 2 m^2. Obviously, the floor must have had some kind of perforation for moving hot air into the firing chamber, but the preserved fragments of the floor did not allow us to reconstruct this likely feature.

The remains of both kilns' firing chambers were traced through notable accumulations of burned clay pieces and granite pieces ringing the upper borders of the furnace chambers. The outer diameter of the ring-like firing chamber's remains in kiln N1 was about 3 m; for kiln N2 it was slightly more than 2 m. Burned clay fragments held impressions of plant stems (possibly straw) on the inside and outer surfaces. It may be inferred that the firing chambers of the kilns had a dome-like shape. The lower levels of the walls were built of granite slabs, then clay was spread on frameworks constructed of some type of plant material at the upper levels. One can suppose that the firing chambers had temporary roofs or covers built after the loading, and destroyed

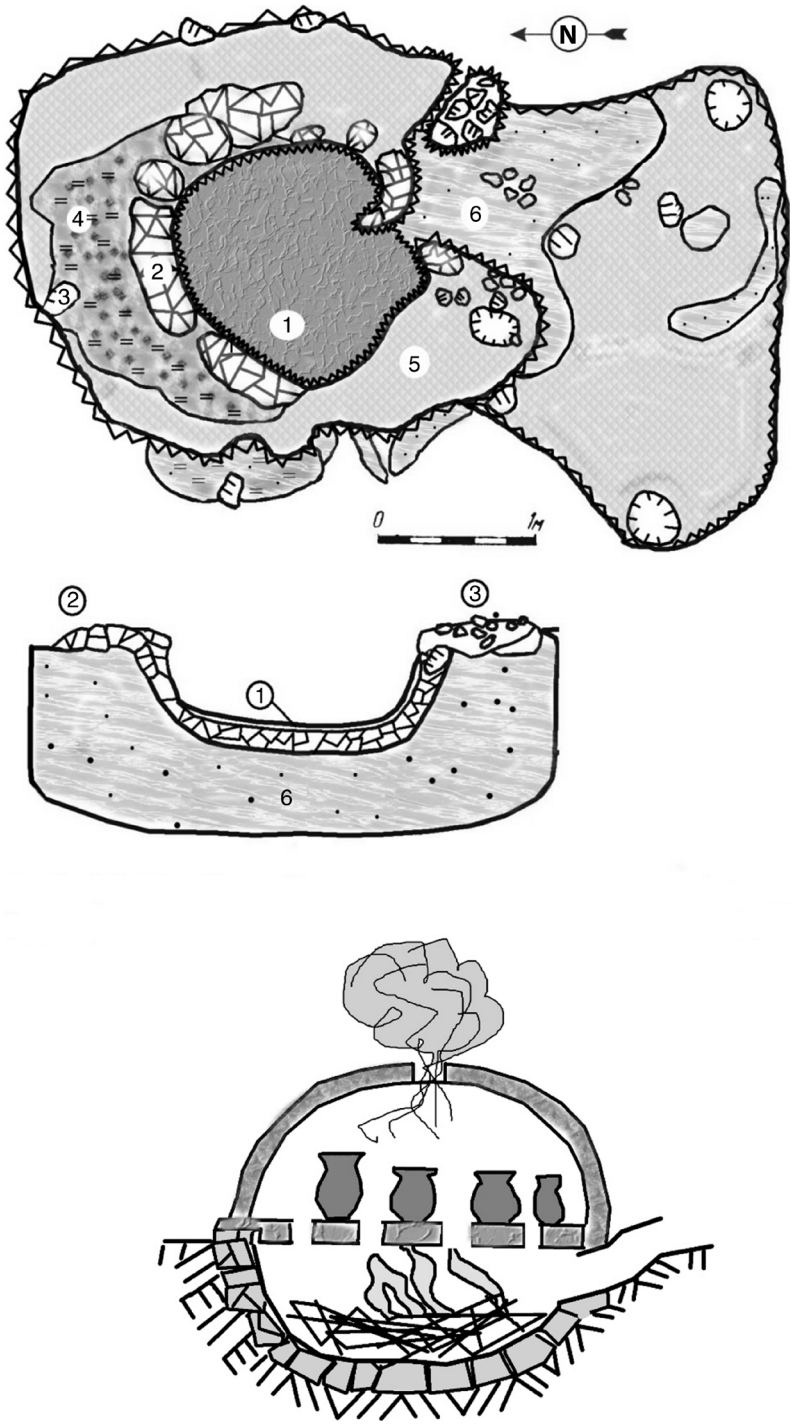


Fig. 6. Kiln N2, a vertical two-level up-draught type: (top) plan—1: chamber bottom (burned clay), 2: granite slabs, 3: pebbles, 4: accumulation of dome fragments (burned clay/straw), 5: light-colored raw clay, 6: sandy soil; (center) profile; (bottom) hypothetical reconstruction. Troitsa site, Pre-State period, Mohe cultural community.

after the firing process. This construction feature is typical of old up-draught kilns (Rice 1987:160, figure 5.22).

Quite close to the southern side of kiln N2, where the probable entrance hole of the furnace chamber was detected, were remains of a small building. The plan of the pit floor formed an 0.8 m depression in the soil. It was shaped in a rough rectangle 2.5 × 3 m in plan view. Three postholes were traced in the floor. An accumulation of plastic raw clay was located near one of the pit's walls. Several fragments of burned clay, small pebbles, and small accumulations of charcoal were unearthed within this presumed structure. It may be supposed that this represented the remains of a subsidiary building for ceramic production work in front of kiln N2.

About 20,000 fragments of ceramic vessels were found around the kilns. Pottery production at both kilns involved mostly handmade small- and medium-sized pots smoothly profiled and decorated along the rim with a narrow appliqué clay strip dissected by vertical incisions. The shape and decoration of the pots are typical for the Mohe culture pottery tradition. Some pottery samples had traces of deformations typically caused by an abrupt increase in firing temperature. In most cases, the pottery was fired in an oxidizing regime that resulted in reddish, yellowish, and light brownish colors on the surfaces and within fractures. Petrographic analysis and chemical analysis indicated that many of the items were produced from clay with natural lime inclusions. Firing temperatures were estimated at approximately 800–850 °C, based on the results of thin-section petrography analysis of ceramic pastes. The petrography study argues that the beginning stages of destruction of lime matter in clay matrix occurs at around 800 °C. However, the temperature was raised to more than 1000 °C inside the fuel chamber, as evidenced by the intense melting of quartz grains in the granite blocks (Andreeva and Zhushchikhovskaya 1986).

Absolute dates for the Troitsa kiln site have not yet been established. However, dates may be assigned on typological terms to the Mohe culture before its inclusion into the Bohai State. Taking into account what is currently known about Mohe history, these kilns may be presumed dated no later than the late seventh century or first half of the eighth century A.D.

FIRING STRUCTURES OF THE EARLY STATES EPOCH: ARCHAEOLOGICAL EVIDENCE

By the middle of the eighth century, part of Primor'e territory was incorporated into the borders of Bohai (A.D. 698–926), a state that also extended into Manchuria and the northern Korean Peninsula. There are many sites of this period in southern, western, and central Primor'e, including walled towns, settlements, and Buddhist temples (Ivliev 2005; Kradin and Ivliev 2008). Later, in A.D. 1115–1234, Primor'e territory and the lands along the Amur River were incorporated into the Jurchen (i.e., Jin) Empire. Numerous walled towns and settlements of the Jurchen period were discovered in the southern Russian Far East; some have been excavated on a large scale (Artem'eva 2005; Len'kov and Artem'eva 2003). Both the Bohai State and the Jurchen Empire were closely connected with the Tang and Song dynasties of Imperial China in terms of their political, religious, cultural, and economic elements and traditions.

There is substantial evidence of well-developed pottery-making technology in Bohai and Jurchen sites in the southern Russian Far East. Both cultures used the potter's wheel and exhibited sophisticated skill in manufacturing roof tiles. Archaeolo-

gists have excavated the remains of firing kilns for manufacturing roof tiles and probably pottery at a number of sites.

The Bohai State Period Kilns

The Kilns of the Walled Town of Kraskinskoe — The remains of 12 firing kilns were excavated between 1980 and 2001 at one of the Bohai State's prominent sites, the walled town of Kraskinskoe in southern Primor'e (Boldin and Nikitin 1999; Boldin et al. 2008) (Fig. 2). Two radiocarbon dates for this site are 1195 ± 35 and 1315 ± 40 years B.P. [AA-36749, AA-36750] (Kuzmin et al. 2005). Kiln remains were located in the northwest portion of the ancient town near a sharply angled town wall and the remains of a small Buddhist temple complex. The kiln remains were concentrated in three distinct areas within this zone. A group of seven kilns was located to the southwest of the main temple pavilion's platform (area 1), two kilns were located southeast of the platform (area 2), and three kilns were located northeast of the platform (area 3) (Fig. 7). In the course of excavations, it was noted that the remains of the kilns had different degrees of preservation and that the kilns had not been built at the same time, so had not functioned simultaneously. In area 1, the researchers identified the earliest kilns as N5 and N9, somewhat later kilns as N6, N7, and N8, and the most recent kiln as N4. These kilns were built consecutively at the same location. Kilns N1, N2, and N4 were the best preserved (Fig. 8). In addition, the remains of a well were unearthed near area 1.

Ten of the excavated kilns (N1–8, N11, and N12) were shaped like elongated, sloped tunnels. Main structural sections included furnace chambers, firing chambers, and flues. The angle of slope of the floors of the firing chambers was about 10–15°. The pits, which resembled furnace chambers, were located at the lower ends of the kiln structures and the flues at the upper ends. The elongated rectangles of the kiln floors were depressed into the earth at 0.3–0.5 m. The total length of the kilns varied from 3.3 to 5.9 m and the width from 0.75 to 2.3 m. In all cases, the firing chambers comprised the largest part of the kiln's total tunnel length.

Only the lower part of the tunnel walls were preserved. The walls were made of stones, mainly pebbles, and fragments of roof tiles. The inner surfaces of the walls were coated with clay. The partitions between the structural sections of the kilns were built of stones and roof tiles. The floors of the kilns were coated with clay that had been burned intensively. Excavations detected evidence for kiln domes that had collapsed and been crushed; the remaining fragments of these domes indicate that they were constructed of clay mixed with cut straw (Fig. 9). It is surmised that the domes were arc-shaped or hemispheres. The clay material from the domes had been burned intensively.

Observations of the best-preserved archaeological remains suggest that the flues were placed at the back upper part of the tunnels. In most cases, flues were located outside the back wall of the firing chambers, but sometimes the flue section was inside the tunnel of a kiln. The remains of kiln N4 shown in Figure 9 present an interesting case of coupled flues.

In all cases, a circular-shaped pit with a depth up to 0.5 m was disposed in front of the furnace section. These pits probably served for fuel storage or containing the debris removed from the furnace chambers. Pits containing raw clay material were located near some of the kilns.

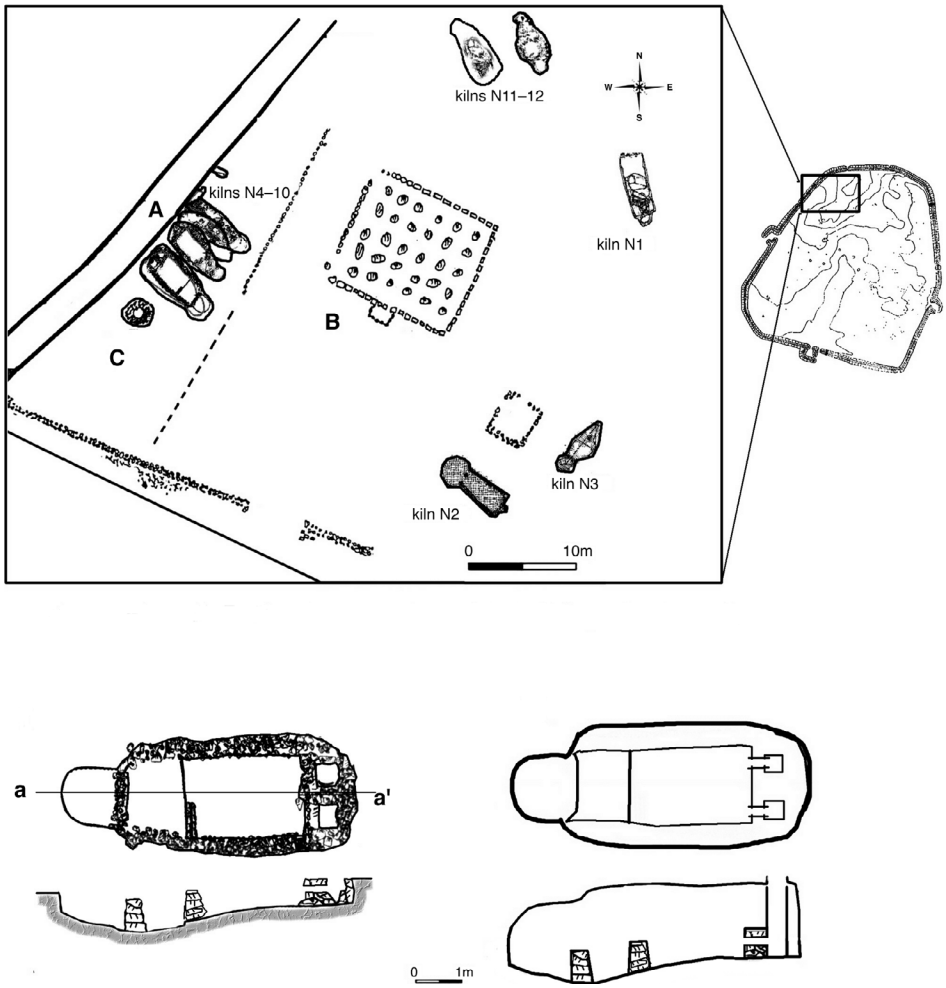


Fig. 7. Kilns of tunnel-like sloping cross-draught type: (top) map of kiln locations within the area of the walled town (A—town wall, B—temple platform, C—well); (bottom) details of kiln N4, including (left) horizontal plan and profile, and (right) hypothetical reconstruction. Kraskinskoe site, Early State epoch, Bohai State.

Not a single kiln was found to contain within the firing chamber roof-tile products prepared for firing. However, samples of ceramic tile wastage, representing tiles damaged during the burning process, were found near the kilns (Fig. 10). One can assume that the tiles sometimes used to construct the kilns were produced locally. Petrographic thin-section analysis of ceramic pastes found that standard tiles had been fired at about 850 °C (Boldin and Nikitin 1999). This is an optimal temperature for the firing of many kinds of raw clay deposits found in southern Primor'e. The firing temperature of the clay matter used to construct the domes was more than 900 °C (Boldin and Nikitin 1999). Judging by the colors of the recovered roof tiles, the craftpeople fired tiles using oxidizing and reducing regimes and smudging. It may be

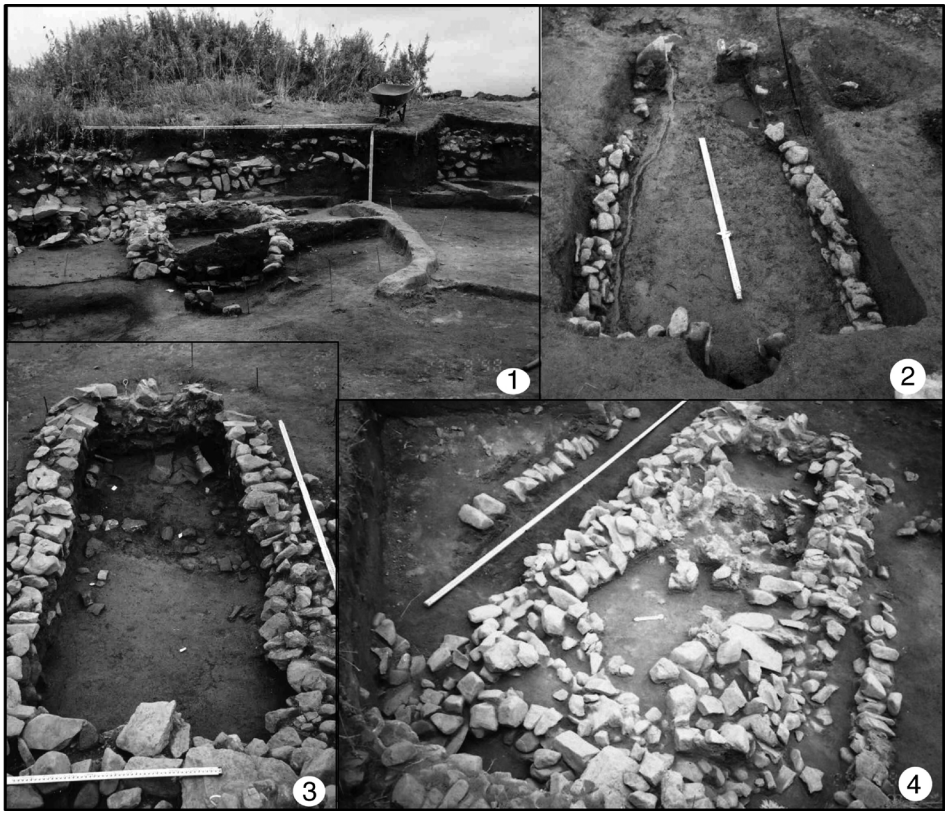


Fig. 8. Photographs of kiln remains of the tunnel-like sloping cross-draught type: 1: area 1, view from southeast, town fencing wall is in the back; 2: remains of kiln N2, view from northwest, flue section at the front; 3: remains of kiln N4, view from northwest, flue section at the front; 4: remains of kiln N7, view from southwest, flue section at the front. Kraskinskoe site walled town, Early State epoch, Bohai State.

supposed that roof tiles fired in these kilns were used locally for building and restoring the Buddhist temple, the remains of which have been recovered at the site. The samples of the temple's roof tiles are very similar in their morphological and decorative features to roof tiles found inside and outside the kilns.

Besides the remains of these tunnel-like kilns with structured inner spaces, the poorly preserved remains of two elongated kilns (N9 and N10) without structural divisions were unearthed in area 1. The remains of kiln N9 were positioned under those of kiln N7, while the remains of kiln N10 did not underlie any another construction. These two kilns were dug into the earth to a depth of 0.4–0.5 m and were shaped like elongated ovals. The length of the preserved parts of both kilns was about 1.5 m, the width about 0.6–0.7 m. No evidence of division into functional sections, fragments of domes, or clay coating on the walls was recorded. There were only weak traces of internal burning of the kilns. In addition, no roof-tile pieces were found inside or outside kilns N9 and N10. Taking these observations into account, what these kilns were specifically used for is still unclear.

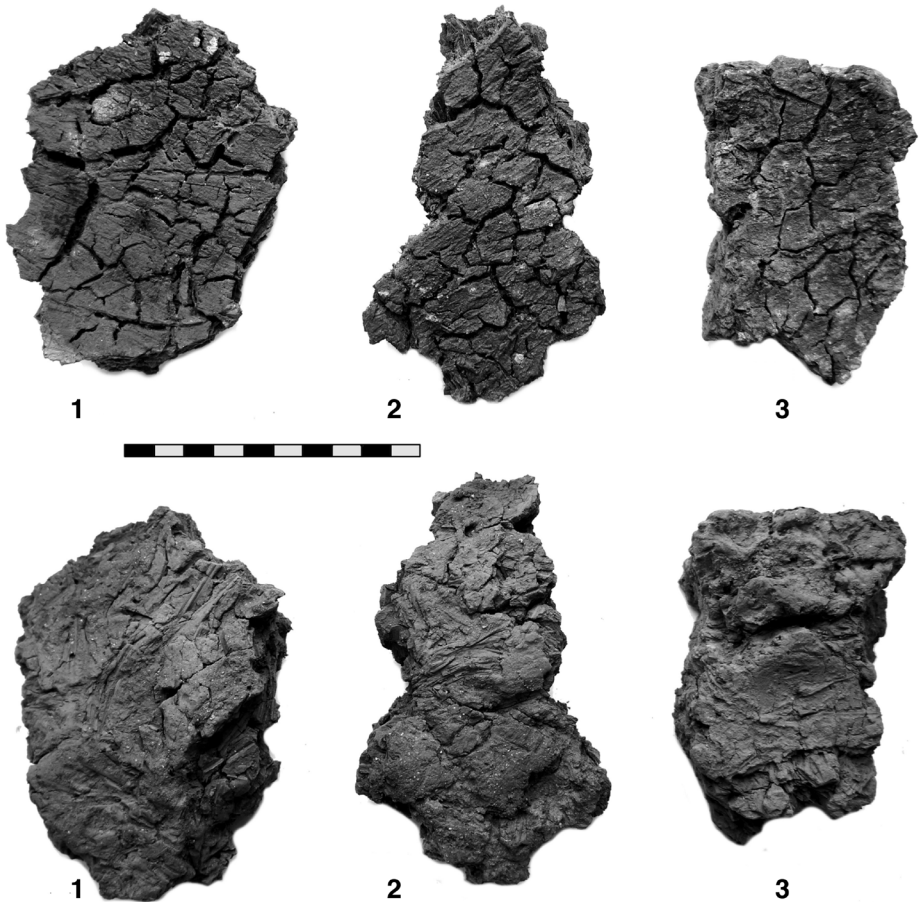


Fig. 9. Three fragments of burned clay with plant impressions from kiln N4 dome: (top) obverse surfaces; (bottom) reverse surfaces. Kraskinskoe site, Early State epoch, Bohai State.

Kilns at Korsakovskoe 1 and 2 — The fragmented remains of five kilns were excavated in western Primor'e near the Krounovka River in the area of the Korsakovskoe settlement (Korsakovskoe-1) and a neighboring Buddhist temple (Korsakovskoe-2) (Boldin 1981; Shavkunov et al. 1994) (Fig. 2). Radiocarbon dates for two kilns located near the temple were reported as 1500 ± 160, 1030 ± 40, and 1090 ± 35 years B.P. (GIN-8289, GIN-8290) (Kuzmin et al. 2005).

Although damaged to some degree, all of the kilns were identifiable as having the same construction as the sloping tunnel-like types of kilns described above. Their characteristics include: an elongated oval-like plan, floor depressed into the soil between 0.7 and 1.3 m, a small arc-like or hemispherical dome, and structural division into three sections (furnace section, firing section, and flue or chimney section) (Fig. 11). The firing sections could be measured in three cases: 2.28 m, 2.20 m, and 1.8 m.

The floors of the kilns sloped slightly, with the firing section and flue placed at a higher level than the furnace. The floors and walls were covered with a layer of dense

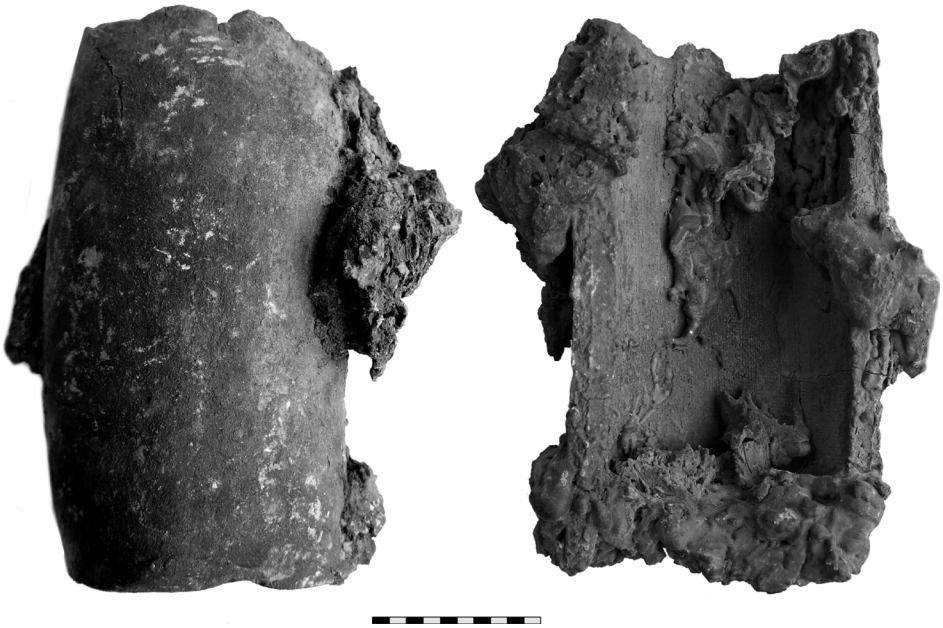


Fig. 10. Sample of roof-tile firing spoilage found near kiln N4: (left) obverse surface; (right) reverse surface. Kraskinskoe site, Early State epoch, Bohai State.

burned clay. In three cases, the kiln domes had collapsed; their remnants indicated that

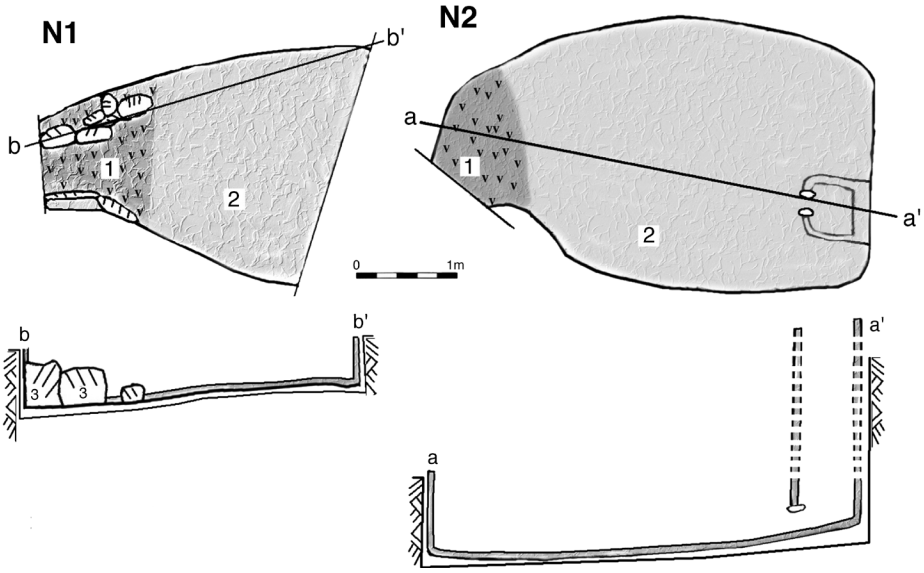


Fig. 11. Remains of (left) kiln N1 and (right) kiln N2, of tunnel-like sloping cross-draught type: (top) horizontal plans at floor level; (bottom) profiles (after Boldin 1981: figures 9 and 10). Korsakovskoe-1 site settlement area, Early State epoch, Bohai State.

they were formed of a clay and straw (grass) mixture. In a single other case, traces of a dome formed of pebble-sized stones adhered to clay were found. The capacity of the furnace sections was small. Furnaces were reinforced by placing stones along the sides. In two cases, archaeologists determined that the flues or chimneys, formed of clay and pebbles, were placed inside the back of the firing chamber. One fragmented tube-like chimney was traced to a height of 1.43 m (kiln N2 at Korsakovskoe-1).

In some cases, tile wastage samples were found near the kilns. This allows us to conclude that the kilns were used for roof-tile firing, although the firing sections were empty of any production. Some roof tiles and fragments of ceramic pots were recovered from inside one solitary kiln. From that we infer that the kilns were likely used for firing pottery as well as ceramic tiles.

Jurchen (Jin) Empire Period Kilns

Kilns at Lazovskoe — Interesting data on structures supposedly functioning to fire ceramic products were obtained in 1980 at the site of Lazovskoe in southern Primor'e. This walled town is dated to the twelfth to thirteenth centuries (Len'kov and Artem'eva 2003). The remains of a workshop area, including several kiln structures, were excavated from a hillslope in the western part of the town. The workshop was a clearly demarcated 50 × 50 m^2 area, oriented along cardinal directions and enclosed by a 1 m high earthen wall. A break in the southern side of the wall served as the entrance. The remains of nine kiln-like structures were located in the eastern part of the workshop complex near the remains of some subsidiary constructions resembling a shed and storehouse along with several pits. In the western part of the workshop complex, the remains of a habitation structure were recorded.

All of the kilns' structural remains were recorded within elongated, narrow trenches depressed into the soil to depths of 0.5–0.6 m. Trenches were 6–7 m long and 0.8–1 m wide. One group of five trenches was situated along the east side of the workshop. A second group that included four trenches stretched from the east side of the workshop perimeter and was perpendicular to the trenches of the first group. Internal structural features appeared to be standardized for all the kilns at the site. At one end of each trench, a furnace pit was reinforced with stones, and a round pit for holding kiln waste products was joined to the furnace pit. Furnace pits and pre-furnace pits were filled with charcoal. The lengths of the firing chambers were 5.5–6.5 m. Firing chamber floors were covered by burned clay layers of 0.02 m thickness. A flue section at the back end of each trench was traced in the form of a pit 0.4–0.5 m in diameter and 0.6 m in depth; flues were clearly of the tube-like type. The floors of some of the kilns were sloped slightly, with the flue sections located at the most elevated level. Other kilns had horizontal floors. The domes of all of the kilns at this site were destroyed, but judging from fragmented remains, they were built of clay on an organic framework.

No ceramic production pieces or firing spoilage samples were found inside or outside the kilns in the area of the workshop. However, the burned clay layer on the floor and the presence of charcoal in furnace and pre-furnace pits indicate that the kilns were actually used. We may suppose that these kilns were intended for firing pottery or roof tiles. It is assumed that ceramics produced at another location were brought to the workshop for kiln firing (Len'kov and Artem'eva 2003 : 29).

Kilns at Sergeevka — The fragmented remains of four kilns located near one another within the boundaries of the modern village of Sergeevka were recognized in 1997. These kilns were 10 km north of the well-known, large, Jurchen period walled town of Shaiga (Vasil'ev 1998, 2009) (Fig. 2). The kilns were located on a stream bank close to raw clay deposits suitable for ceramic production. The kilns had been intensively damaged by the farming activities of modern villagers. Kiln N1 was relatively better preserved than the others, however, enabling archaeologists to determine some features of kiln construction in this area (Fig. 12).

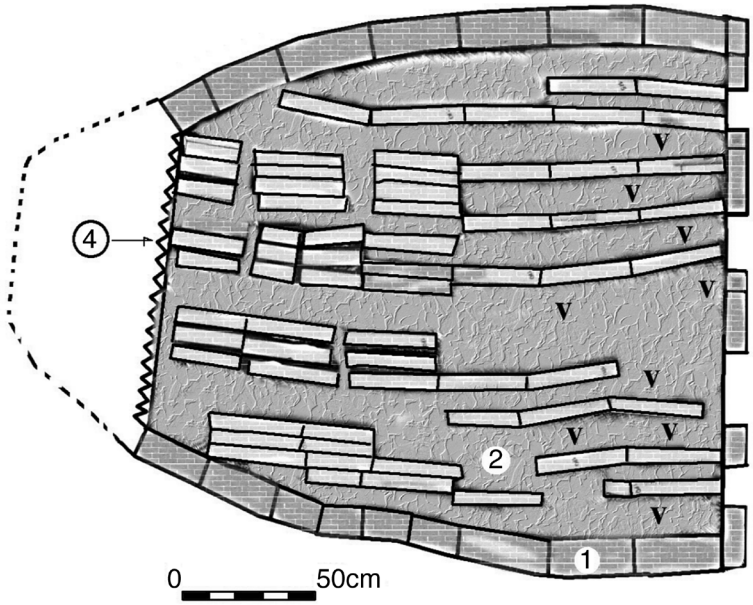
The remains of kiln N1 indicate that it was clearly divided into a firing chamber and fuel pit. The furnace located at the front of the kiln was almost entirely destroyed, but it was determined that the bottom of the furnace lay at a lower level than the floor of the firing chamber. The firing chamber, built of adobe bricks, was 1.97 m in length, 1.62 m in maximal width, and approximately 1.5 m in height. The long sides of the chamber had slightly convex contours, while the short sides of the chamber, both front and back, were straight. Therefore, the horizontal plan of the firing chamber was similar to an oval with flattened ends. The dome of the firing chamber had collapsed on to the floor; it was constructed of clay mixed with brick and tile pieces.

The floor was formed out of a flattened, rammed, and burned clay ground surface 0.05–0.07 m thick. At the back wall of the firing chamber at floor level, four flue channels, each 0.08 m wide, were detected. Unfortunately, a large part of the back wall and the area beside it were entirely destroyed. Several rows of bricks lying at the ribs paralleling the long axis of the firing chamber were unearthed above the floor. The firing chamber was entirely filled with burned roof tiles (Fig. 13). The tiles were deposited compactly in four levels, with each level consisting of several horizontal rows of tiles oriented in an upright position. For instance, the lower level contained 376 tile samples arranged in five rows; these tiles overlay the bricks on the floor.

Judging by the color of the roof tiles, they were fired in an oxidizing regime and then partially clouded by smoke in the firing chamber. The roof tiles were fired evenly throughout their thickness of 2–2.5 cm. The Mohs hardness scale index of the tile samples is 5–5.5. The firing temperature was estimated at around 850–900 °C. Therefore, the firing process in this kiln had been completed, but the fired tiles were never removed from the kiln.

Kiln N2 was almost entirely destroyed. Only the floor of the firing chamber and lower part of the back brick wall were recovered. Four flue channels were located in the back wall at floor level. Traces of brick rows similar to those in kiln N1 were recorded over the firing chamber's floor, interpreted as an arrangement of standing tiles intended for improved hot air circulation during the firing process.

Kilns at Pokrovka-1 — The remains of seven kiln-like structures were excavated in the 1990s. They were sited on the east bank of the Ussuri River at the Pokrovka-1 site, in territory bordering the Primor'e area and the lower Amur River (Deryugin 2000) (Fig. 2). The cultural deposits at that site were preliminarily dated to the twelfth to thirteenth centuries and were extensively damaged. The poorly preserved remains of the complex included a rectangular building with columned construction, surrounded along two sides by kiln-like firing structures and pits. No clear function was inferred for the structure associated with the kilns. Based on fragmentary excavation data, it is possible to reconstruct only some limited characteristics of the kiln-like firing structures.



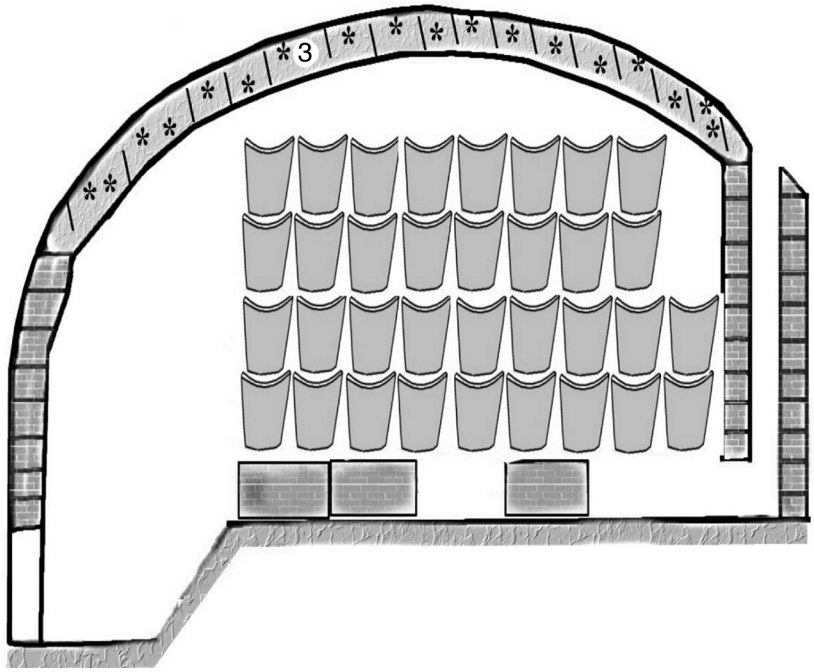


Fig. 12. Kiln N1 of *manthou* down-draught type: (top) horizontal plan at floor level—1: bricks, 2: burned clay layer on floor, 4: line separating firing chamber from deeper fuel chamber, V: traces of ash (after Vasil'ev 1998: figures 23, 27, 28); (bottom) hypothetical reconstruction in profile view—3: clay dome. Sergeevka site, Early State epoch, Jurchen (Jin) Empire.

Fig. 13. Two sample roof tiles from kiln N1: (top) obverse surfaces; (bottom) reverse surfaces. Sergeevka site, Early State epoch, Jurchen (Jin) Empire.

The firing structures that were traced had an elongated shape that could be described as oval and they were depressed into the soil to a depth of around 0.3 m. There is no evidence of sloping in the kiln floors. In some cases, the excavations detected structural divisions of the kilns into furnace, firing, and flue sections. A better preserved kiln, N4, had a 2 m diameter circular fuel chamber separated by a partition of stone pebbles from the oval-shaped firing chamber, which measured 4.2 m in length and 2.5 m in width. The traces of the stone-built flue section were recorded at the back of the firing chamber. The kiln floors were covered by a clay layer or layer consisting of small-sized rock debris mixed with charcoal. The clay walls and floors of the kilns had traces of burning. The kiln domes likely were formed of clay mixed with cut straw. Numerous fragments of burned clay were found within the area encompassed by the kilns' remains.

Within some of the kilns, a few fragments of roof tiles were found. In addition, outside the kilns, and particularly in the pits associated with them, significant numbers of fragments of roof tiles and broken ceramic pots were unearthed. There is no information on whether ceramic wasters were found in the area of the kilns. According to their technological, morphological, and decorative features, the roof tiles and pottery are deemed similar to those from Jurchen (Jin) Empire period sites.

DISCUSSION

The data presented in this article allow us to outline the temporal frameworks and historical dynamics of ancient ceramic firing structures in the Russian Far East, and to correlate these with the archaeological record of firing technology development for pottery and tile manufacture in neighboring regions of East Asia. Different types or kinds of firing structures, as distinguished in the course of our study, are summarized in Table 2.

We infer certain causal links between the appearance of the earliest kiln-like pottery firing structures and the process of developing metal production in the southern Russian Far East. First, the simplest kilns appeared in the Palaeometal period, approximately 1000 B.C. through the fourth/fifth centuries A.D., when some methods of metal thermal processing were adopted by the prehistoric populations of Primor'e and the lower Amur River area. Some direct evidence of thermal processing of metals is known for Primor'e Palaeometal period sites (Klyuev and Gridasova 2013; Kon'kova 1989 : 47–48).

Examination of pottery from the Palaeometal cultures shows a steady increase in firing temperature indexes in comparison with Neolithic period pottery. Average firing temperatures of ceramics associated with the Primor'e Yankovskaya and Krounovskaya cultures are estimated at 700–800 °C (Zhushchikhovskaya 2005 : 76, table 3.6). The average firing temperature of pottery from the lower Amur Uril'skaya culture, dated to the first millennium B.C., is estimated to be 700–800 °C, with firing temperatures sometimes reaching 900–1000 °C (Grebenshchikov and Derevyanko 2001 : 34–37). In investigations of prehistoric Russian Far Eastern pottery-making traditions, the assumption is that progress in pottery-firing technology during the Palaeometal period was catalyzed by the invention of metal thermal processing technology.

The pottery kilns or ovens of the Yankovskaya culture were of primitive ground-level, dome-like, and single-chambered construction built of clay on a perishable

TABLE 2. TYPES OF ANCIENT CERAMIC FIRING STRUCTURES IN THE SOUTHERN RUSSIAN FAR EAST

CHRONOLOGY AND CULTURAL CONTEXT	TYPE OF FIRING STRUCTURE, NOTING BUILDING MATERIALS	APPROXIMATE FIRING TEMPERATURE AND REGIME
Palaeometal period, Yankovskaya culture, c. 1000 B.C. to 3rd/2nd centuries B.C.	Oven-like single-chambered, ground-level up-draught kiln; clay on plant framework	700–800 °C; oxidizing
Palaeometal period, Krounovskaya culture, c. 4th century B.C. to 4th/5th centuries A.D.	Simplest variant of tunnel-like sloping cross-draught kiln; clay on wooden framework	700–850 °C; oxidizing, smudging
Pre-State period, Mohe culture, c. 4th through 8th centuries A.D.	Two-level up-draught kiln with underground fuel chamber and dome-like firing chamber; stone, clay	800–850 °C; mostly oxidizing
Early States epoch, Bohai State period, A.D. 698–926	Tunnel-like, sloping cross-draught kiln; stone, clay	850–900 °C; oxidizing, reducing, smudging
Early States epoch, Jurchen (Jin) Empire, A.D. 1115–1234	1. Tunnel-like cross-draught kiln 2. Single-chambered down-draught kiln (*manthou* type).	850–900 °C (supposed); oxidizing, reducing, smudging

vegetative framework. Such firing structures were likely used in prehistoric pottery making of some Eurasian regions. Ovens of this type are presumed to have two openings, including one for loading fuel and another placed in the back wall or in the top of the dome to create a draught (Bareš et al. 1982 : 191–208, 223). In the course of experimental research, a model of a simple oven reproducing the probable form of excavated firing structures was constructed and tested. This small oven was made of a clay-grass mixture pasted on a frame made of plant material (Fig. 14). Testing of this pottery oven model showed that such a structure is suitable for firing pottery at temperatures up to 700–800 °C (Zhushchikhovskaya 2005 : 77–78).

In the southern Korean Peninsula, the earliest pottery kilns of the simple pit type assigned to the late Bronze Age (fifth century B.C. to A.D. 0) were unearthed at the site of Taegok-ni. Estimated firing temperature in these kilns was between 573 and 870 °C (Barnes 1992 : 204). It is known that, at the excavated Ban'po site, the earliest Neolithic Chinese pottery kilns dug entirely into the soil were of two construction types, including vertical up-draught forms and horizontal or slightly inclined forms (Shangraw 1977). Therefore, it seems likely that the construction diversity of the earliest pottery kilns in various regions of East Asia reflect the variability of engineering choices at the very initial stage of development of specialized thermal processing structures.

Single firing structures known from the later Krounovskaya culture of the Palaeometal period seem to be of quite another construction type. They appear to be the simplest and most rustic variant of the tunnel-like kiln. It is important to note that the kiln at the Chernyatino-2 site, dated preliminarily to the first centuries A.D., displayed features such as floor sloping, depression into the earth, and a dome built on a wooden frame. This kiln may be correlated closely with the oldest southern Korean elongated kiln excavated at the Taegok-ni site and dated to the end of the Proto–Three Kingdoms period at the terminal third to the early fourth centuries A.D.

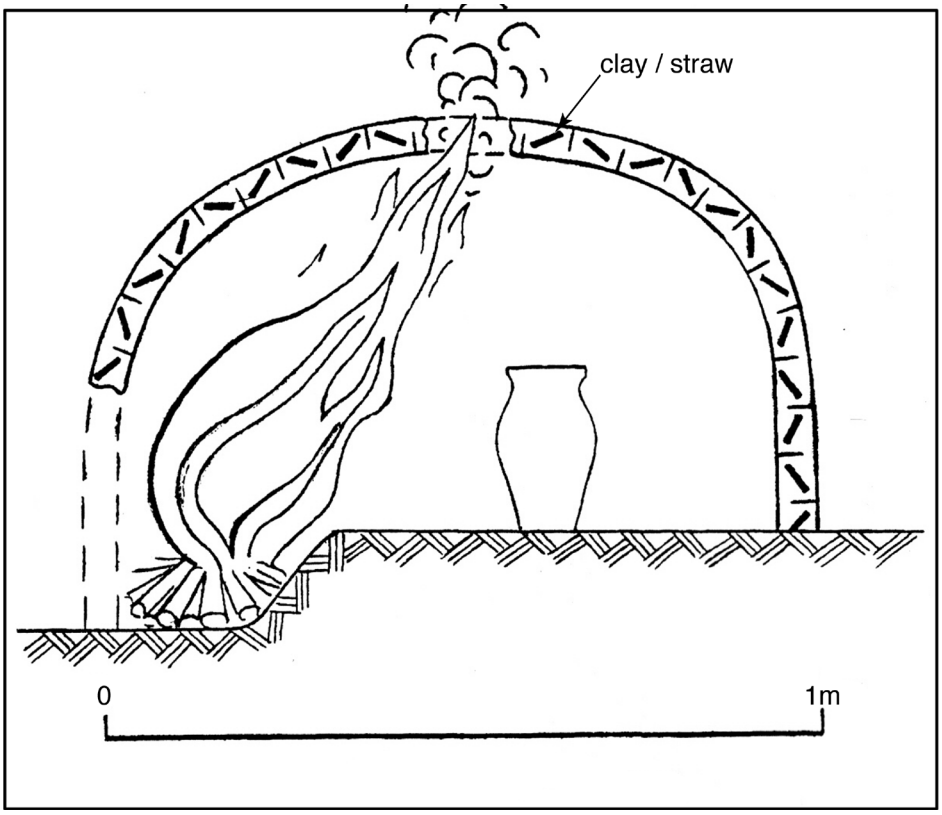


Fig. 14. Experimental kiln of simplest one-chambered type, built of clay/straw mixture on plant frame.

The kiln had an elongated form dug into the earth, a slightly sloped floor, a fire pit section, a firing chamber, and a flue section. The total length of the kiln was 6.3 m, while the maximal width was 3.7 m. The fire pit section had a circular-like shape, while the firing chamber was of a clear, elongated tunnel–like shape (Barnes 1992 : 204). Archaeological work has revealed that the Krounovskaya culture of Primor'e was related closely to its contemporary Tuanje culture of neighboring eastern Manchuria and some cultural traditions of the Proto–Three Kingdoms period of the Korean Peninsula (Lin 1985). The spread of these shared design elements of tunnel-like kilns over the Korean Peninsula and bordering areas of Primor'e during the first half of the first millennium is interpreted as the result of a process of cultural intercommunication.

It was argued that the tunnel-like, elongated and sloped, cross-draught, "long" type of pottery kilns came to the Korean Peninsula from China, where this type was invented and developed in the southern regions during the Warring States period (475–221 B.C.). Essential constructive features of the long kiln are a tunneled body with the furnace at one end and the flue at the opposite end, a sloping and ascending floor, and an arcing dome. The first Chinese long kilns had a length of about 6 m, while in the course of time the kiln lengths increased up to many dozens of meters (Barnes 1992 : 202; Kerr and Wood 2004 : 347–360; Li 2009; Shimada 2009). First

appearing in Korea during the Proto–Three Kingdoms period, this kiln type was adopted and developed right up until the recent past. The characteristic traits of excavated Korean tunnel-like, sloped ceramic kilns, in comparison to the developed Chinese long kilns, are short length and the absence of an ascending structure for the firing chamber (Carrico 1973; Osgood 1952 : 61, 263–264; Rha 2006 : 111–112). The technological and construction principles of long kilns greatly influenced firing structures for pottery and tiles in some regions of Southeast Asia and the Japanese archipelago (Hein 2008; Kerr and Wood 2004 : 356; Shimada 2009).

In the southern Russian Far East, the period of Early States was the time when the idea of elongated firing kilns, or "long" kilns, spread in the region. At the Bohai State sites of Primor'e, only the remains of tunneled kilns are found. It is likely that the main construction principles of these kilns were related to early elongated kiln structures of the Korean Peninsula unearthed at fourth-century sites (Barnes 1992 : 204–205). At the same time, the sizes of Bohai tunnel-like kilns excavated in Primor'e appear to be significantly smaller than the early Korean kilns. The maximum length of the Primor'e kilns reaches 5.9 m, while the length of Korean kilns of the fourth century is up to 7.8 m (Barnes 1992: table 3). We have no data on ceramic firing kilns at Bohai State sites in Manchuria. So, it could be assumed preliminarily that in Manchuria tunnel-like kilns similar to those unearthed in Primor'e were known during the Bohai State period.

During the period of the Jurchen (Jin) Empire (A.D. 1115–1234) in the southern Russian Far East, two different types of firing kiln structures were known. One was the tunnel-like elongated kiln type recorded at the Lazovskoe walled town and probably at the Pokrovka-1 site. It must be noted that elongated kilns at these sites do not seem to be more technologically developed, elaborated, or larger in comparison with the Bohai State period's tunnel-like kilns. Furthermore, such an essential constructive feature of the tunneled kiln as a sloping floor is not characteristic of all the excavated Jurchen period kilns. It is interesting that some of the kiln structures excavated within the same workshop area at the Lazovskoe walled town had slightly sloped floors, but others had floors without any discernible sloping. For example, no clear sloping was recorded for the kilns excavated at the Pokrovka-1 site. It may be suggested that the Jurchen tunnel-like kilns corresponded to the ideals of tunneled kiln construction to a lesser degree than the Bohai State's kilns. It may be noted that we do not know exactly what kind of ceramics production—pottery or roof tiles—took place in the elongated kilns of the Jurchen (Jin) period.

Another type of kiln structure connected unquestionably with roof-tile firing was recorded at the Sergeevka site. Distinctive features of this kiln type include a compact one-chambered structure; the use of bricks as building material; a dome-like upper part of the firing chamber; and floor-level flue channels in the back wall of the firing chamber. This type seems to be similar to the *manthou* (steamed bun) kilns characteristic of northern China beginning in the mid-first millennium. The *manthou* kiln is also called a "horseshoe-shaped" kiln, because its horizontal plan is reminiscent of a horseshoe footprint. These kilns were used for firing porcelain, stoneware, and roof tiles. The *manthou* firing structure was built of bricks on ground level and had a compact corpus of a firing chamber with vertical walls, hemispherical ceiling, and two chimneys beside the back wall. The furnace chamber was located lower than the firing chamber. The flue channels were placed in the rear part of the kiln at floor level. The *manthou*, in its developed variant, was constructed as a down-draught kiln.

During firing, hot air from the fuel section rose naturally to the kiln's ceiling, then was forced down and passed outward through the flue channels (Barnes 1992:202, 203; Gerritsen 2012:168; Hein 2008:2; Kerr and Wood 2004:314–334). The construction features of the Sergeevka site's kilns have certain similarities with *manthou* kiln type. Due to the near-total destruction of the anterior parts of these kilns, we can reconstruct only hypothetically that two chimneys were located beside the back wall. Therefore, it is likely that during the Jurchen (Jin) Empire, the technological aspects of *manthou* kilns came to the southern Russian Far East.

An intriguing research problem is the origin of the up-draught vertical kilns excavated at the Troitsa site and assigned to the Mohe cultural community of the fourth to eighth centuries. These kilns represent a quite separate line of firing-structure development in the southern Russian Far East and East Asia as a whole. No clear analogies to these kilns are known from the same ages in China, the Korean Peninsula, or the Japanese archipelago. Pottery firing structures with a vertical disposition of the lower fuel chamber and the upper firing chamber were used in China during the Neolithic and Shang periods, together with other types of firing constructions (Barnes 1992:202; Shangraw 1977). There is no definitive information about the use of vertical two-level kilns in pottery-making and tile-making crafts during the late Zhou period and the following centuries of Chinese history. Similarly, there is not clear information on vertical two-level up-draught kilns in the ceramic production crafts of Korea and the Japanese archipelago.

The geographically closest region for the use of vertical up-draught pottery kilns, round in plan, with a fuel chamber dug into the soil, and with a grate separating fuel and firing chambers, is Central Asia, where these kilns existed from the Bronze Age to the medieval epoch. As researchers note, this type of pottery kiln appeared in southern Central Asia at Bronze Age settlements in the late third millennium B.C. From the second millennium B.C. to the eighth century A.D., vertical up-draught kiln construction developed and spread over vast territories of Central Asia. From the ninth to the twelfth centuries, significant innovations to kiln construction increased the technological level of the firing process (Saiko 1982:144–162). The vertical pottery kilns of Central Asia shared a common line of development in firing structures with the kilns of the Near East. In the latter region, vertical, circular-plan, up-draught kilns were invented by 6000 B.C., and this type of firing structure continued to be developed and used in pottery production of later periods (Simpson 1977*a*, 1977*b*).

Two probable versions of the origin of vertical up-draught kilns in the Mohe community pottery production may be suggested. The first version hypothesizes that this type of firing structure may have been invented independently by Mohe potters. However, the probability of this supposition being correct is not high because the technological level of Mohe pottery making, in particular the absence of pottery wheels, coupled with their semi-nomadic mode of life, would not favor the development of engineering innovations in pottery kilns. The second theory suggests that the idea for vertical up-draught kilns was imported by the Mohe population from those regions where this type of firing structure was used, and in this case evidence indicates that the most likely region of origin was Central Asia. Taking into account the traditionally high mobility of Mohe tribes and the close connections of some of them with populations in the Steppe Corridor area, the second scenario, focusing on borrowing construction models for firing structures from interregional and intercultural contacts,

appears to be the least improbable. In general, the reasons for and sources of vertical up-draught pottery-firing kilns, in a territory where another kiln construction model was dominant, may be determined in future research.

It is important to say some words about the patterns of localization of old kiln remains. In most of the cases considered here, the kiln remains are located compactly within areas containing artifact assemblages and features indicative of a wide range of cultural activities. The tendency of kilns to be located within ancient settlements areas, rather than external to habitation, is noted for the Palaeometal period and for the Early States epoch. In two cases dated to the Bohai State period, the localization of the kiln remains was recorded nearby supposed Buddhist temple remains. Most likely, the kilns produced roof tiles for temple building and reconstruction needs. In one case dated to the Jurchen (Jin) Empire, kiln assemblages were noted within a workshop zone of a site. A frequent observation in many of the world's regions, and particularly East Asia, with regard to evidence for firing kilns in both the distant past and more recently, is that these kilns are often localized within workshop complexes representing other types of production activities and stages of manufacture, and often near a water source.

CONCLUSION

We reviewed the archaeological record of the history of ceramic firing structures in the Russian Far East from late Prehistory to the Early States epoch. The Palaeometal period (about 1000 B.C. through the fourth/fifth centuries A.D.) was the time when, simultaneously with the invention of metals production, the first primitive kilns for earthenware firing were established. It appears that during this period, the technology of tunnel-like kiln construction in its simplest variant appeared in the southern Russian Far East, in the context of Krounovskaya archaeological culture related closely to the cultures of eastern Manchuria and the Korean Peninsula (Subbotina 2008).

During the Early States epoch, from the eighth to the thirteenth centuries, tunnel-like kilns proliferated in the ceramic production crafts of the Bohai State (A.D. 698–926) and the Jurchen (Jin) Empire (A.D. 1115–1234). The southern Russian Far East, together with the Korean Peninsula, Japanese archipelago, and some regions of Southeast Asia, was included within the vast area of tunneled kiln use, developed from the long kilns of southern China. It must be emphasized that the tunnel-like kilns excavated in the southern Russian Far East are very close in style to the Korean model of tunneled kiln, differentiated from the Chinese long kilns by their comparatively small size and the absence of the stepped structure of the firing chamber's floor.

Our comparison of the data on excavated kiln remains allows us to note that in the southern Russian Far East during the Jurchen (Jin) Empire, firing structures of the *manthou* or horseshoe-shaped type of kilns were found contemporaneously with the tunneled kilns. The *manthou* kilns certainly were used for production of roof tiles. These firing structures at Russian sites seem to have their origins in the *manthou* kilns of northern China. A separate type of firing structure unearthed in the research area is presented by two kiln remains assigned to the Mohe cultural community and dated preliminary to the Pre-State period of the fourth to eighth centuries A.D. These vertical, two-level, up-draught kilns with a furnace chamber dug into the earth have no similarly dated counterparts in neighboring areas of East Asia. The closest region

where ceramic kilns of this type were known from the late Bronze Age to the medieval epoch was Central Asia. The reasons for, and factors in, cultural contact associated with the appearance of vertical kilns in the southern Russian Far East seem to be separate research subjects that require significantly more study. We do not exclude the possibility that this phenomenon might be the result of long-distance cultural interconnections between the Russian Far East and these distant regions.

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ABSTRACT

Archaeological records reveal the history of pottery and roof-tile firing devices in the southern part of the Russian Far East, the neighboring Korean Peninsula, and northeast China. Chronological parameters are from the first millennium B.C. through the thirteenth century A.D., including the Palaeometal period of the Prehistory epoch, Pre-State period, and Early States epoch. Different types of firing kilns varied in complexity of form and technology, including the tunneled sloping kiln, *manthou* kiln, and vertical up-draught kiln. These specific characteristics reflect the involvement of the ancient southern Russian Far East in the processes of cultural interaction within the larger East Asia region. KEYWORDS: southern Russian Far East, ceramic firing kilns, Prehistory epoch, Pre-State period, Early States epoch.