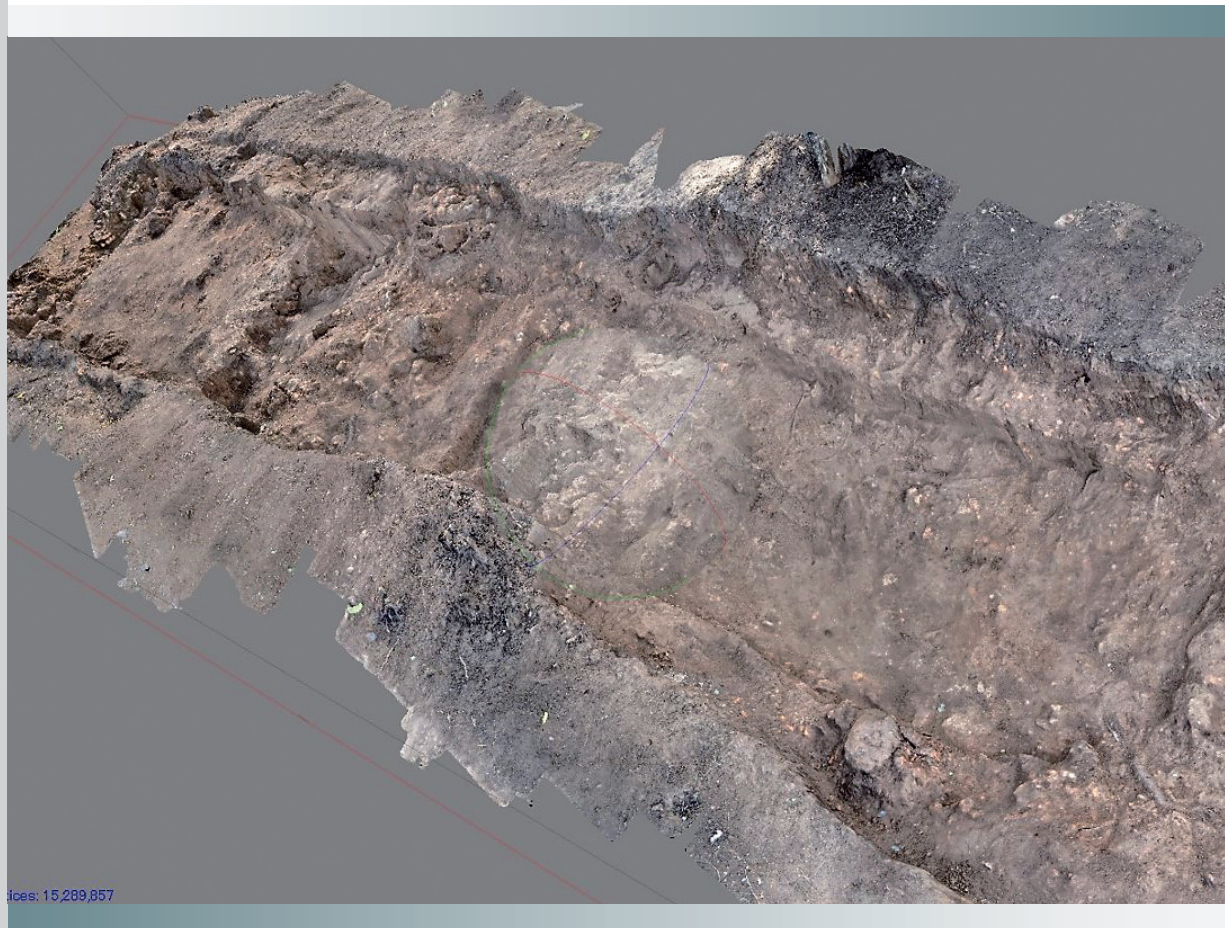


The Veal Kok Treas Kilns I

An Archaeological Investigation at a Brown-Glazed Stoneware Production Center in Cambodia

Yukitsugu TABATA (ed.)



May 2021

APSARA National Authority

Institute for Cultural Heritage, Waseda University

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Introduction

Yukitsugu TABATA

The Veal Kok Treas kiln is one of many newly discovered premodern stoneware kilns located east of the Angkor monuments. Until the early 2000's, all of the stoneware kilns identified in the Angkor area were located around the Phnom Kulen mountain and found to have produced unglazed stoneware or stoneware with a transparent green-colored glaze (ash-glazed ware) only. Therefore, studies on the Angkorian kilns in Cambodia had focused on ash-glazed and unglazed stoneware production. The kilns responsible for the distinctive Khmer-style brown-glazed stoneware, which is commonly unearthed from Angkorian sites, were known only from around the present Thai-Cambodian border—Buriram and Surin Provinces in northeast Thailand, and Banteay Meanchey Province in northwest Cambodia (Tabata, Sato, Sok et al. 2015, 57). Under those conditions, most of our understanding of Khmer brown-glazed stoneware was based on these Thai-based studies and thus, led to the claim that Khmer brown-glazed stoneware was brought to Angkor from present-day northeast Thailand (Brown 1988: 55).

This situation changed in the past ten years due to the discovery of brown-glazed stoneware kilns along the ancient road—la voie royale from Angkor to Preah Khan of Kampong Svay (Hendrickson 2008). Following this discovery, the Authority for the Protection and Management of Angkor and the Region of Siem Reap (APSARA National Authority, Cambodia), the Institute for Cultural Heritage, Waseda University (ICHWU, Japan) and the Nara National Research Institute for Cultural Properties (NNRICP, Japan) have been conducting a joint research project of the newly found brown-glazed stoneware kilns in the Siem Reap region since 2013. The first joint archaeological excavation was conducted on the Veal Svay kiln from 2013 to 2015, and the basic structure of the kiln (a single-chambered cross-draft kiln) was clearly defined (Nara National Research Institute for Cultural Properties 2017).

Parallel to our research, two neighboring kilns, Torp Chey and the Chong Samrong, were chosen for joint-investigations with the research teams of these kilns claiming to have found a unique kiln structure. Judging from their reports, the basic kiln structure at Torp Chey and Chong Samrong seems to be the same as those at Veal Svay, which are: a clay-made, single-chambered cross-draft kiln; a step between the ware-chamber and firebox; and, clay pillars on the central axis of the kiln body. But, Torp Chey and Chong Samrong have a unique kiln element: a secondary firing trench in the ware-chamber. It was a trench, cross-cutting the chamber. The members of the Torp Chey and Chong Samrong projects, especially Ea Darith and Don Hein claim that these trenches were used to put in additional fuel during firing to maintain the temperature of the ware chamber (Ea 2016, 60, Hein, Cort, Ea et.al. 2013, 26–27).

Contrary to these two kilns, we could not identify any archaeological features to indicate a secondary firing trench at the Veal Svay kiln. This fact led us to a hypothesis that Veal Svay might be older than Torp Chey or Chong Samrong (13th to 14th century) and thus its structure bears some resemblance to older ash-glazed stoneware kilns in the Angkor area (the date of ash-glazed stoneware kilns in Angkor are around the 10th to the 11th centuries). However, 14C dating shows that Veal Svay dates from the late 13th to the late 14th centuries (NNRICP 2017, 22). With reference to the present understanding of dating Khmer brown-glazed stoneware—the 11 or 12th century to the 14th centuries, the late 13th century kiln is difficult to be seen as either a prototype or transitional stage from the ash-glazed type to the brown-glazed type. The structure of the Khmer brown-glazed stoneware kilns needs further study and, in response to the situation, we conducted a full-scale excavation to clarify the structure of the brown-glazed stoneware kiln in the Veal Kok Treas kiln group. The research was conducted on the following schedule;

- First session: 13rd–27th August 2016
- Second session: 19th–26th December 2016
- Third session: 21st–28th December 2017



Fig. 1 First Session(August, 2016)



Fig. 2 Second Session(December, 2016)



Fig. 3 Third Session(December, 2017)

1. The Site

Yuni SATO, SOK Keo Sovannara, Yukitsugu TABATA

To date, several Angkorian kilns have been identified and excavated in Siem Reap province. These are Tani, Bankaong, Khnar Por, Sar Sei, Anglong Thom, and newly discovered brown-glazed stoneware kiln. The kilns in Siem Reap Province all seem to be located on the eastern flatlands of the Angkor sites (Fig. 4). The author has pointed out that the distribution pattern of these kilns corresponds to the land development of this area in the Angkor period (Tabata 2007, 2008, 2009).



Fig. 4 Known Khmer Stoneware Kilns

As outlined in the Introduction, brown-glazed stoneware kiln groups have been identified along the ancient arterial road running east-west from the capital of Angkor to one of the largest centers in the late Angkor period: Preah Khan of Kampong Svay. These kiln groups lie approximately 15-25km east of Beng Mealea temple: a large Hindu monument built in the early 12th century. Kiln groups are identified along both the north and south sides of the ancient road, and several archaeological remains—the Torp Chey temple, Arogayasala (hospital), and stone bridges—are also recorded along the road.

The Veal Kok Treas kiln group is one of the brown-glazed stoneware kiln groups located in the Beng Mealea commune, Banteay Srei district, about 20 km east of Beng Mealea temple (Fig. 5). It is nearly 1km south of the ancient road from Angkor to Preah Khan of Kampong Svay via Beng Mealea. About 1km further south of this kiln, at least 7 kiln mounds were found and

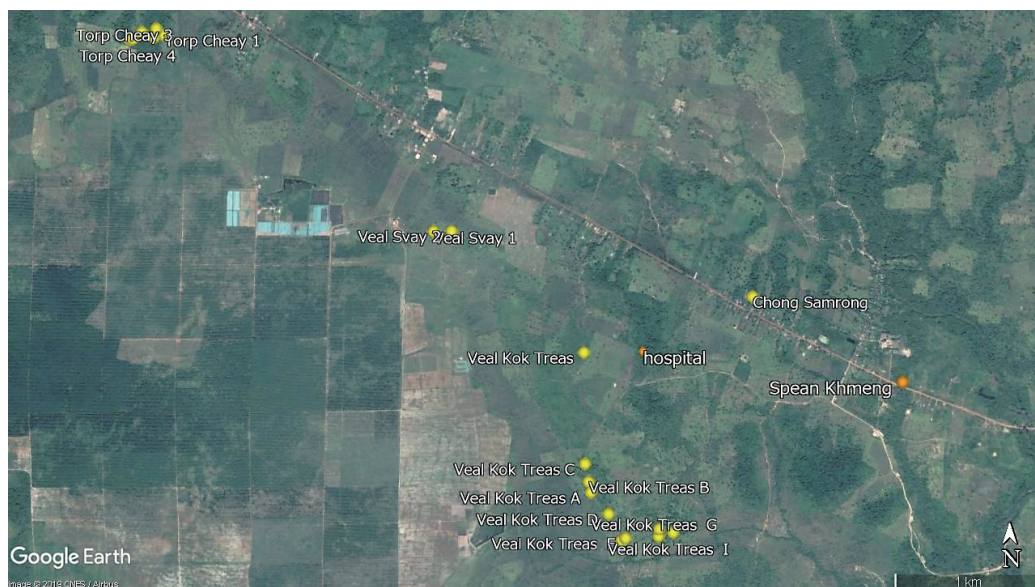
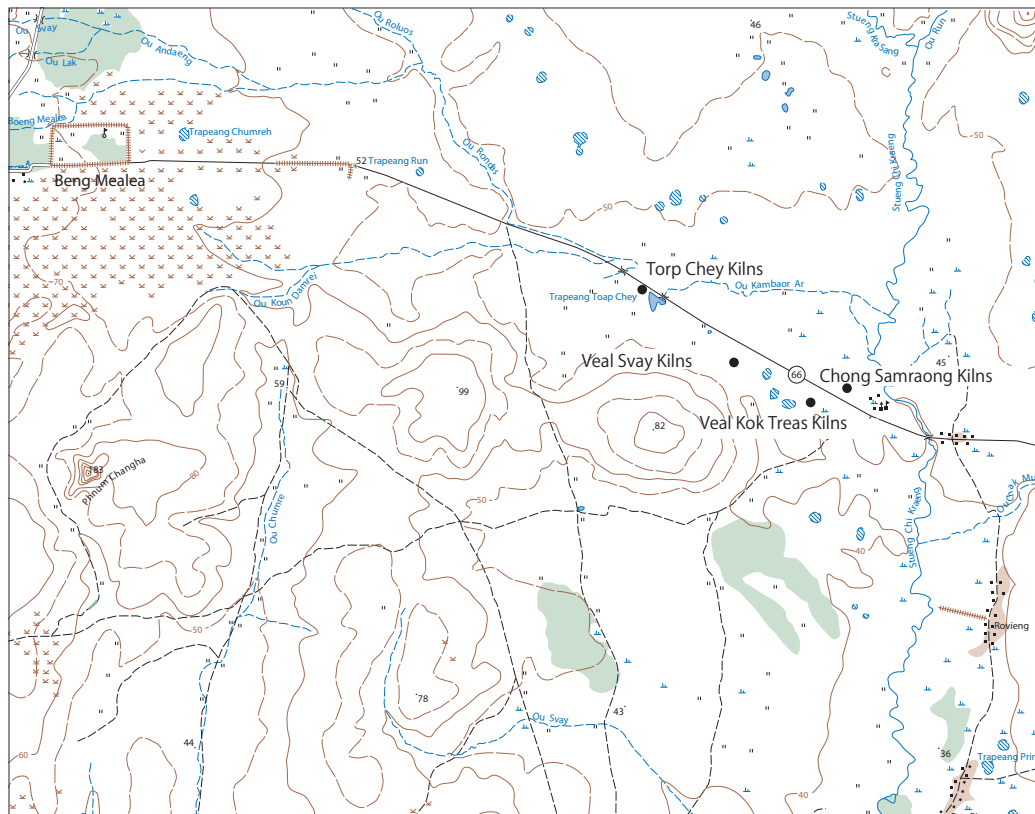


Fig. 5 Location of the Newly Discovered Brown-Glazed Stoneware Kilns (above) and the Veal Kok Treas Group (below)

temporarily designated as Veal Kok Treas kilns A to G, although they are under the threat of imminent destruction due to land developments (Fig.6).

In terms of neighboring kilns, the kiln 1km east-northeast of Veal Kok Treas is the Chong Samrong kiln excavated by the APSARA and Smithsonian Institute in 2013. The Torp Chey kilns are located approximately 2.5km west-northwest of Veal Svay and was excavated by the APSARA and Singapore University at the end of 2012. The quite small area along the ancient road is dotted with significant numbers of kiln groups. Unfortunately, in spite of many efforts to protect the sites by Cambodian and foreign archaeologists, large numbers of the kiln mounds in this area have already been destroyed by land development without any archaeological documentation. But the surviving kiln groups are enough to certify that the area was a large-scale production center of brown-glazed stoneware in the Angkor period.



Fig. 6 The Veal Kok Treas Mound (Kiln #1)



Fig. 7 The Veal Kok Treas Mound (Kiln #1)



Fig. 8 Remnant Side Wall of the Kiln

2. The Features

Hiroshi SUGIYAMA, Yuni SATO, SOK Keo Sovannara

Mound

The site consists of an earthen mound containing possible kiln bodies (Figs. 6 and 7). The surroundings of the mound might have been used for the working area, and subsequently used for discarding kiln furniture, misfired products and ash forming the waste heap.

The mound was relatively larger than other excavated kilns in the Angkor region. The size of the mound is 25.8m from north to south, 24.1m from east to west, and approximately 3m high. It slopes gently from south to north. A part of the side wall of the kiln was exposed in situ around the southern top of the mound, and the outline of the kiln body could be easily understood. This kiln was designated as kiln #1. It was possible that there could be multiple kilns in this mound, as seen in the Khmer brown-glazed stoneware kilns in Northeast Thailand, due to the size of the mound. Trench #1, orthogonal to the north-south main axis of the mound was designed to examine the existence of other kilns. Since the side walls were already exposed (Fig.8), the location of kiln #1 was easily estimated and trench #2 was set up for close examination of it. In addition, trenches #3 to #6 were also set up to confirm the waste heap (Fig. 9).

Only one kiln was identified in trench #1—although, it was set up to see if more than one kiln was constructed. A single kiln per mound was also confirmed at the Veal Svay, Chong Samrong and Torp Chey kilns (Ea 2016, Hein, Cort, Ea et.al. 2013, Nara National Research Institute for Cultural Properties 2017). It is possible that this is a common tendency throughout the surrounding black-brown glazed stoneware kiln groups.

Kiln #1

The kiln #1 was a clay-made, single-chambered cross-draft kiln built on the artificial mound(Fig. 10). The plan of the kiln

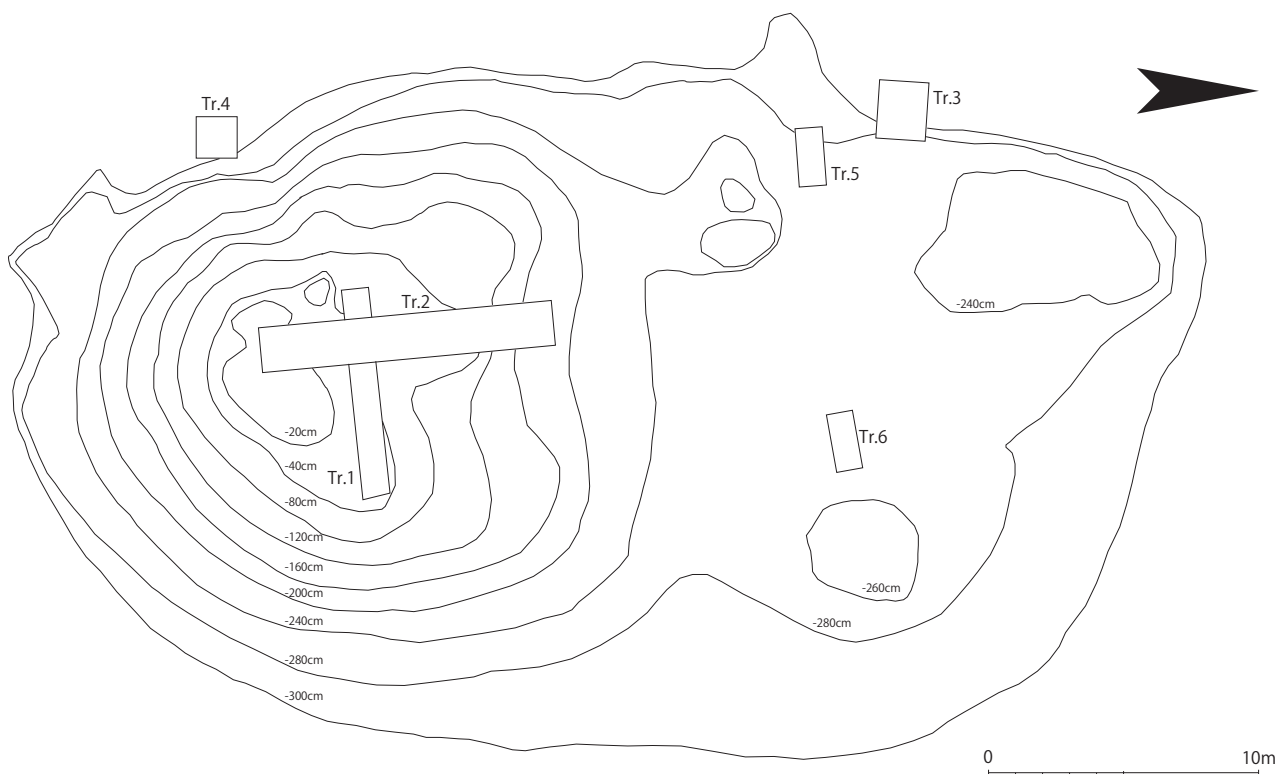


Fig. 9 The Mound and the Trenches

was a narrow rectangle with rounded corners (Fig. 11). It appears that the structure of the kiln consisted of three components: a draft vent, a ware chamber, and a firebox. The floor of the ware chamber is gently angled following the slope of the mound. A step separating the firebox from the ware chamber—clearly observed in other kilns—had collapsed and seemed to be damaged during the kiln's operation. No trace of the draft vent remained because the upper structure of the kiln had not survived, though it must have existed on the roof or upper end of the ware chamber. The entrance hole for loading the product into the ware chamber was also unidentified (Figs. 12–15). The size of the kiln body was about 14.5m long with a maximum width of 2.3 m.

The broken wall or roof of the kiln includes trace of the bamboo-like plant's trunk and leaf (Fig. 16, 17). They have survived as voids in the clay surface and this fact suggests that the ancient potters made the kiln frame with plants and covered it with clay.

Details of the operation of the kiln were hard to understand. The north front of the firebox was totally collapsed and thus, the air holes and fuel loading holes could not be identified. In addition, the obviously low-fired and weakly sintered clay floor in the ware chamber was heavily damaged, which made it quite difficult to examine the method for loading, stacking and firing throughout the operation. No older floors that would indicate any repair or reconstruction of the kiln was observed under the present floor. Considering these facts together, the most rational interpretation is a fairly small or short-term operation at this kiln, in terms of the scale of production.



Fig. 10 The Mound and Kiln #1

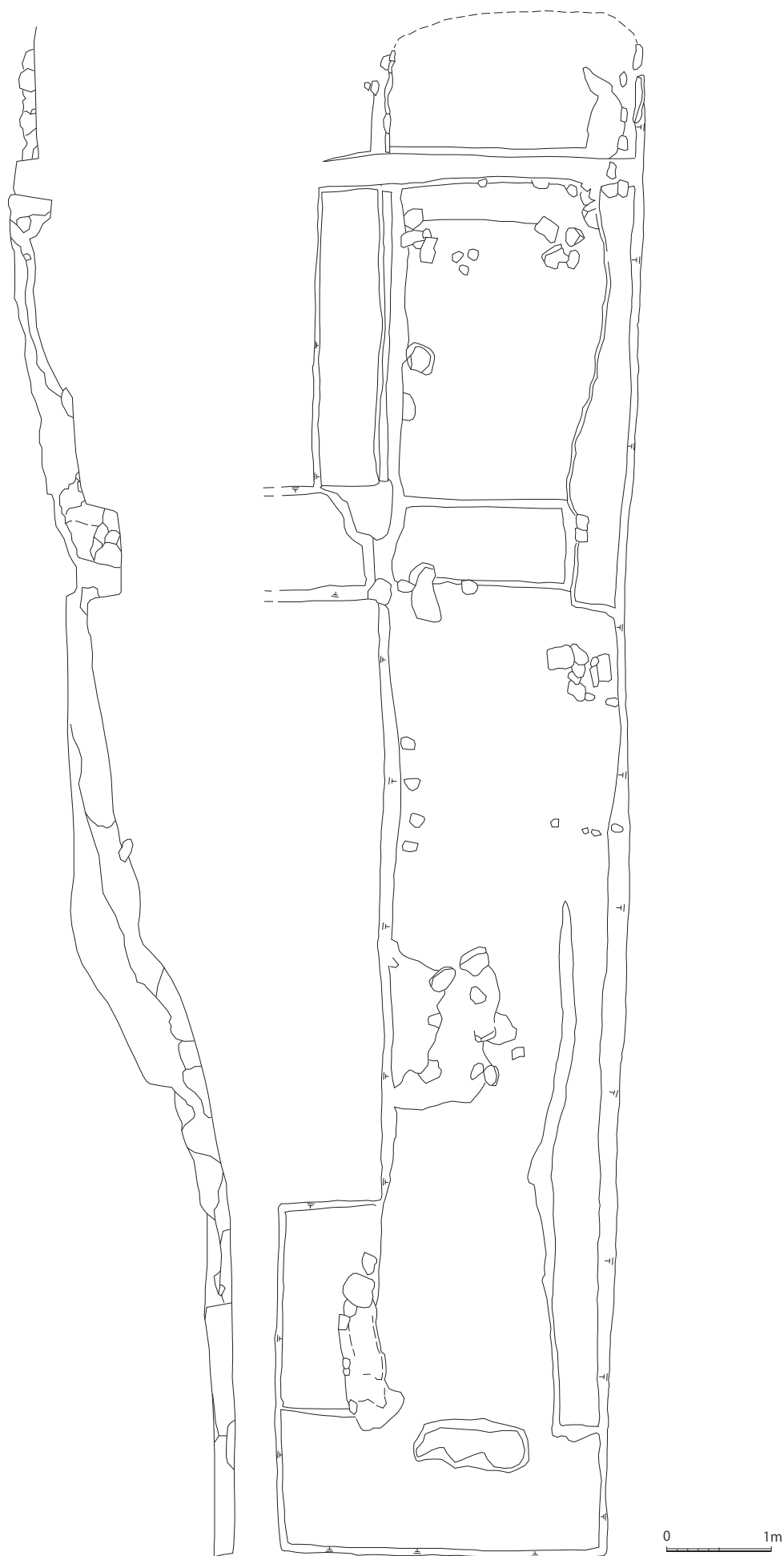


Fig. 11 Plan and Cross-Section of Kiln #1

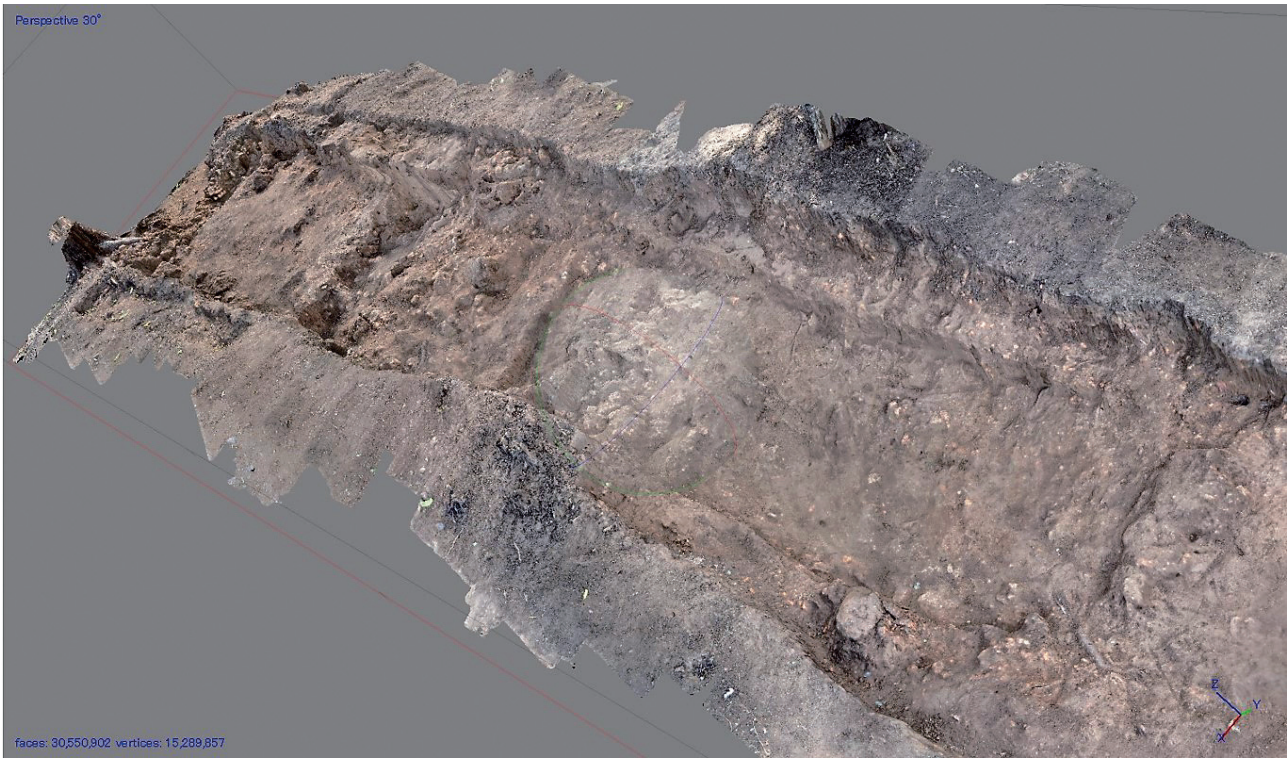


Fig. 12 Kiln Body (3D Image)



Fig. 13 Firebox and Ware Chamber



Fig. 14 Kiln End



Fig. 15 Kiln End



Fig. 16 Side Wall



Fig. 17 Side Wall

3. Artifacts

Hiroshi SUGIYAMA, SOK Keo Sovannara, Yukitsugu TABATA

Almost all of the artifacts, brown-glazed and unglazed stoneware, were excavated from the waste heap (trenches #3 to #6). The repertoire of the products was limited, as seen in the surrounding kilns. These are identified as the storage ware: long-bodied jars, four-ear-lugs jars, and basins or vats. A small number of fine-clay unglazed stoneware with unique decoration, brown-glazed stoneware sherds with animal motifs, and brown-glazed roof tile ware were also unearthed.

Brown-glazed ware (Figs. 18–30)

Fig. 18-1, 3 to 5 show the rims of wide-mouth jars with thin glazing. Some of these types of jar (e.g., Fig.18-5) might have a pedestal, the so-called baluster jar. Fig.18-6 shows the lid of a jar with a leek-flower shaped knob, and similar instances can be found at the Khmer kilns in Northeast Thailand. Conversely, there is no similar instance of Fig. 18-2 elsewhere. It seemed to be an up-side-down shallow basin at first glance. Though, the upper surface (normally corresponding to the bottom of a basin) is well glazed, but the lower end (edge of rim, if this was an up-side-down vessel) is unglazed. The diameter and the height of the inside of the body was well matched to cover the mouth of a large long-bodied jar. Thus, this product is tentatively attributed to the lid of a long-bodied jar.

Fig. 20-1 to 3 are basins. The shoulder part of these basins were decorated with incised combing and stamps.

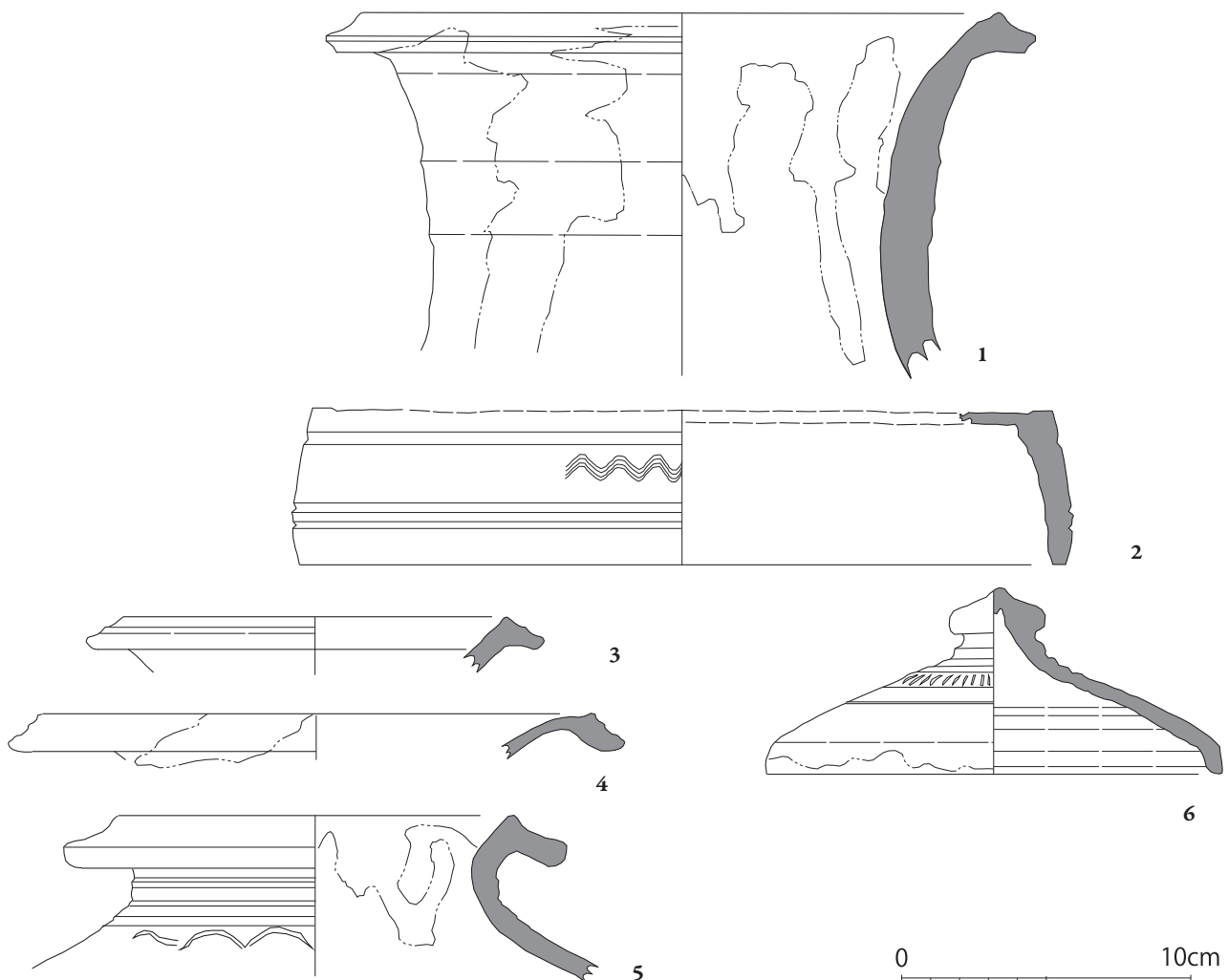


Fig. 18 Brown-Glazed Ware



Fig. 18-1



Fig. 18-5



Fig. 18-2



Fig. 18-6

Fig. 19 Brown-Glazed Ware

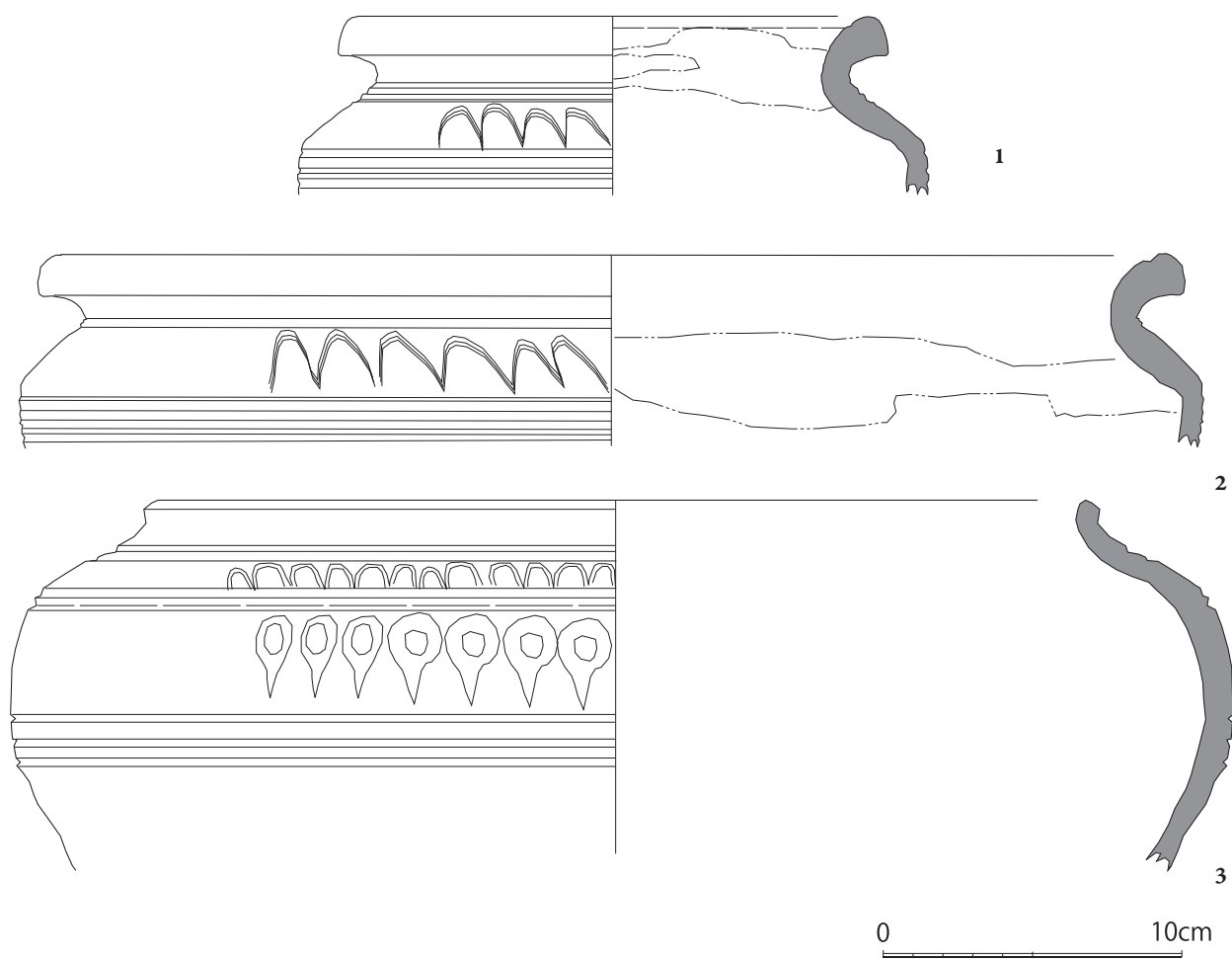


Fig. 20 Brown-Glazed Ware

One of the most noteworthy discoveries of this excavation was the nearly complete brown-glazed, long-bodied jar excavated from the waste heap in Trench #5 at waste heap (Figs. 21 to 25). Since it was found in an upright position, it seemed at first that this jar had been set up intentionally such as water storage. But through careful examination of the soil layers from which this artifact was unearthed, traces of digging to set up the jar (for example, a cut for a small pit) were not detected in the cross-sectional view of the trench (Figs. 21 and 22). This jar must have been deposited in the upright position by chance. A crack made during the firing, of about 10cm in length, was observed in the middle of the body after cleaning the artifact. This kind of crack made the jar difficult to function as storage and support the above presumption.

The size of this jar is 59.5cm high, 17.2 cm diameter at the mouth, 40cm diameter in the body, and 24.0cm diameter at the bottom (Sugiyama 2019: 5). Decoration of the neck consisted of a horizontal band of incised lines. Eight overlapping arcs represented by parallel incised lines are followed by neck decoration. Four incised horizontal lines and scalloped-shaped combed decoration was arranged on the body. The lower part of the body has five roughly scraped steps. The base is flat and about 2 cm thick. Lustrous, blackish-brown-glazing covers the jar until about 10 cm above the base. The glaze at the shoulder flows down towards the bottom and it shows that this jar was loaded into the ware chamber in an upright position. Judging from close observation of the inner surface, the jar was molded with fine reddish-brown clay coils. The base and the body seem to be made separately because the traces of clay bonding were observed on the inner surface, about 11cm above the base.



Fig. 21 Brown-Glazed Jar from Trench #5



Fig. 22 Brown-Glazed Jar from Trench #5

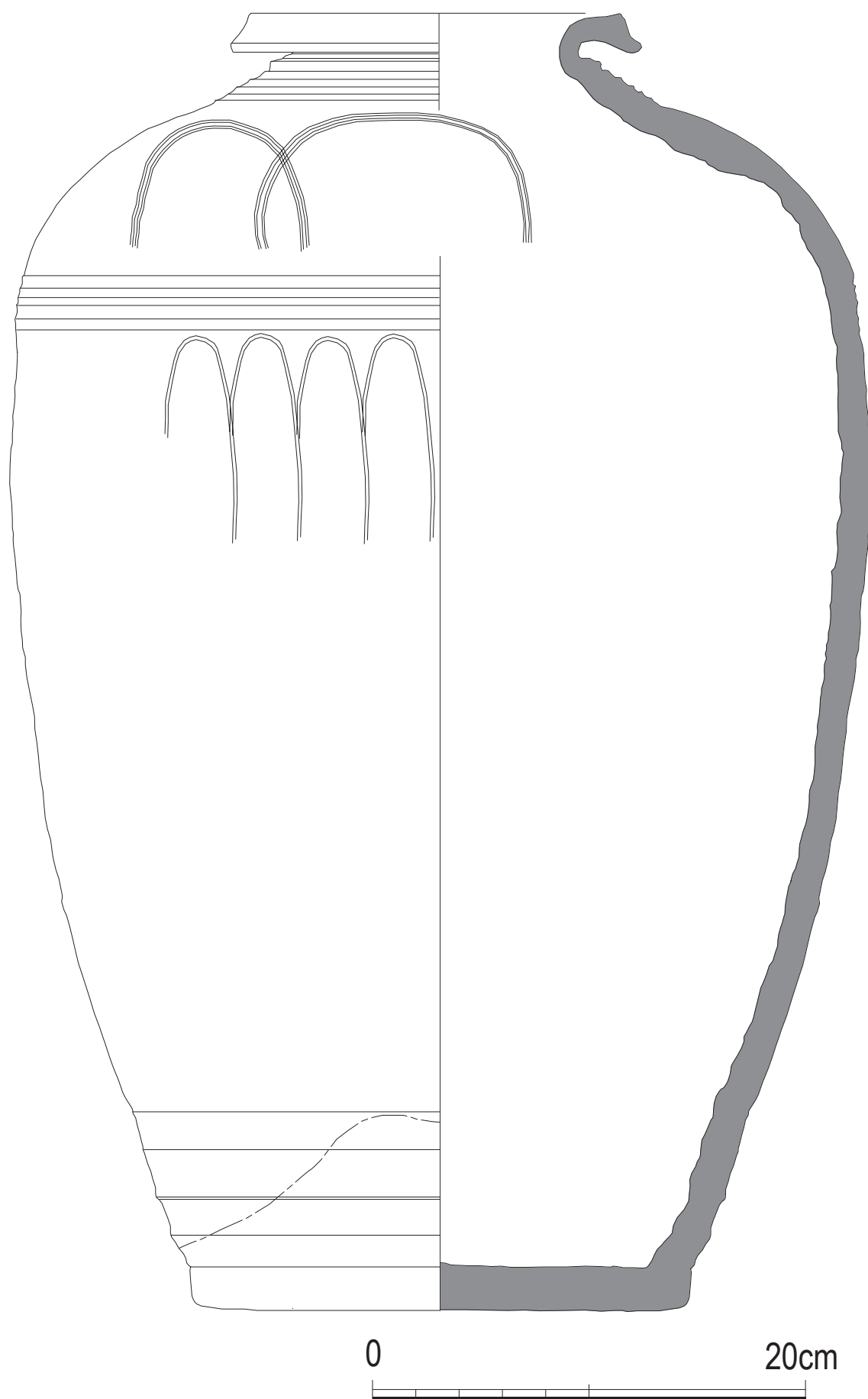


Fig. 23 Brown-Glazed Jar from Trench #5



Fig. 24 Brown-Glazed Jar from Trench #5 (front)



Fig. 25 Brown-Glazed Jar from Trench #5 (back)

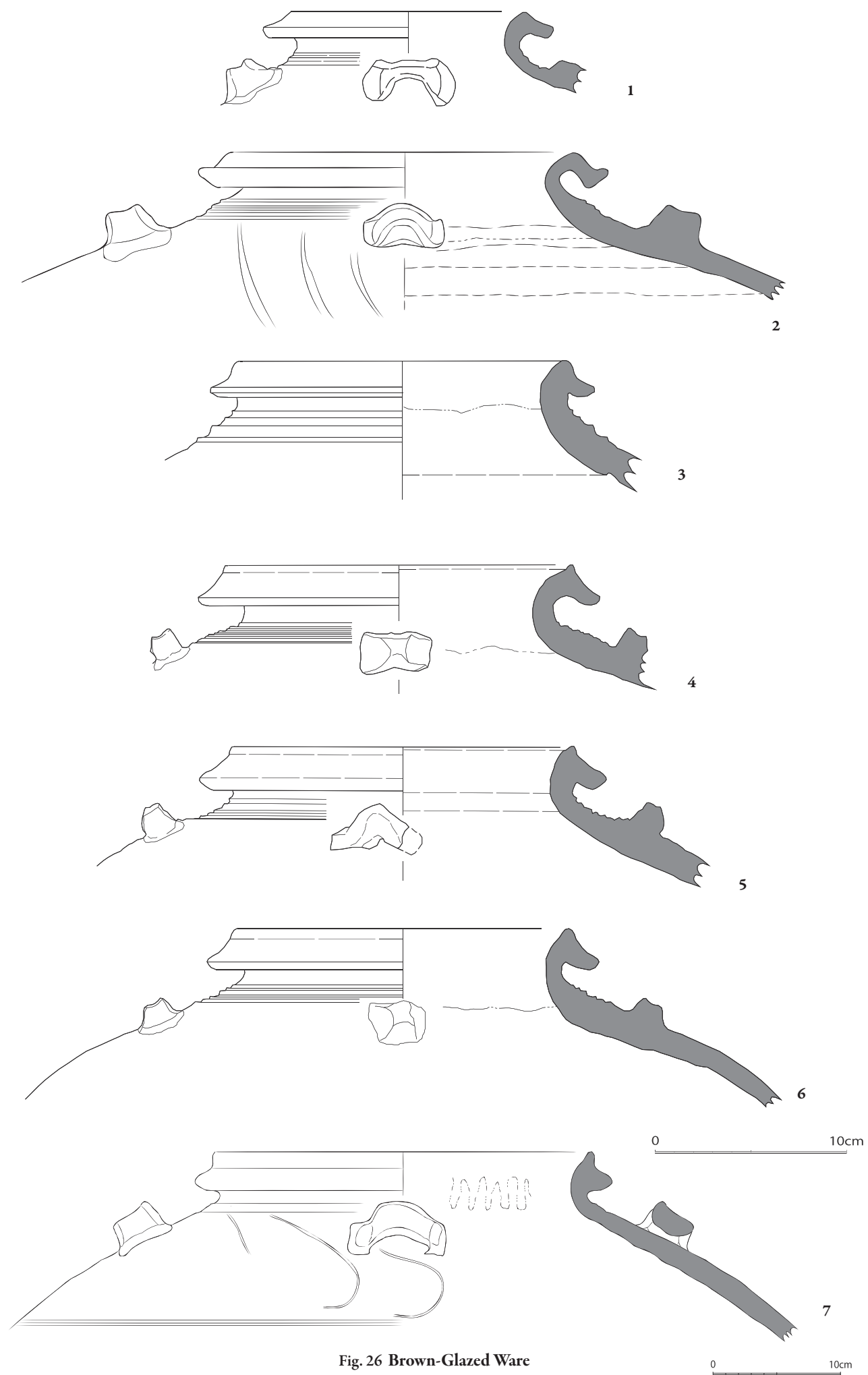


Fig. 26 Brown-Glazed Ware



Fig. 26-2



Fig. 26-4



Fig. 26-7

Fig. 27 Brown-Glazed Ware

Figs. 28 and 29 shows the bottom of the jar. In all cases, the decoration was banded horizontal lines. There were no combing decorations on the base as normally observed on the brown-glazed jars from northeast Thailand.

Fig. 28-3 shows a side hole on the lower part of the jar. There is a 1.6 cm diameter hole about 3 cm above the base that was created during the formation process, not after firing. While an unglazed jar with a hole (created before firing) in the base has been previously excavated from an ash-glazed/unglazed stoneware kiln—the Tani kiln B4—a brown-glazed jar with a hole on the body seems to have a different function to it. In any case, the fact that, a hole was formed before firing suggests a special type of storage with limited uses.

A similar example of the jar with a side hole was unearthed from Ta Nei temple (Tokyo National Research Institute for Cultural Properties 2019, 67–69). Fig. 30 was excavated from the north side of Ta Nei's approach road that runs from the east gopura (tower gate) to the East Baray (reservoir). Due to the identical clay, decoration, glazing and holing, the jar excavated from the Ta Nei temple is presumed to have been produced at either the Veal Kok Treas kiln or at least in the surrounding kilns.

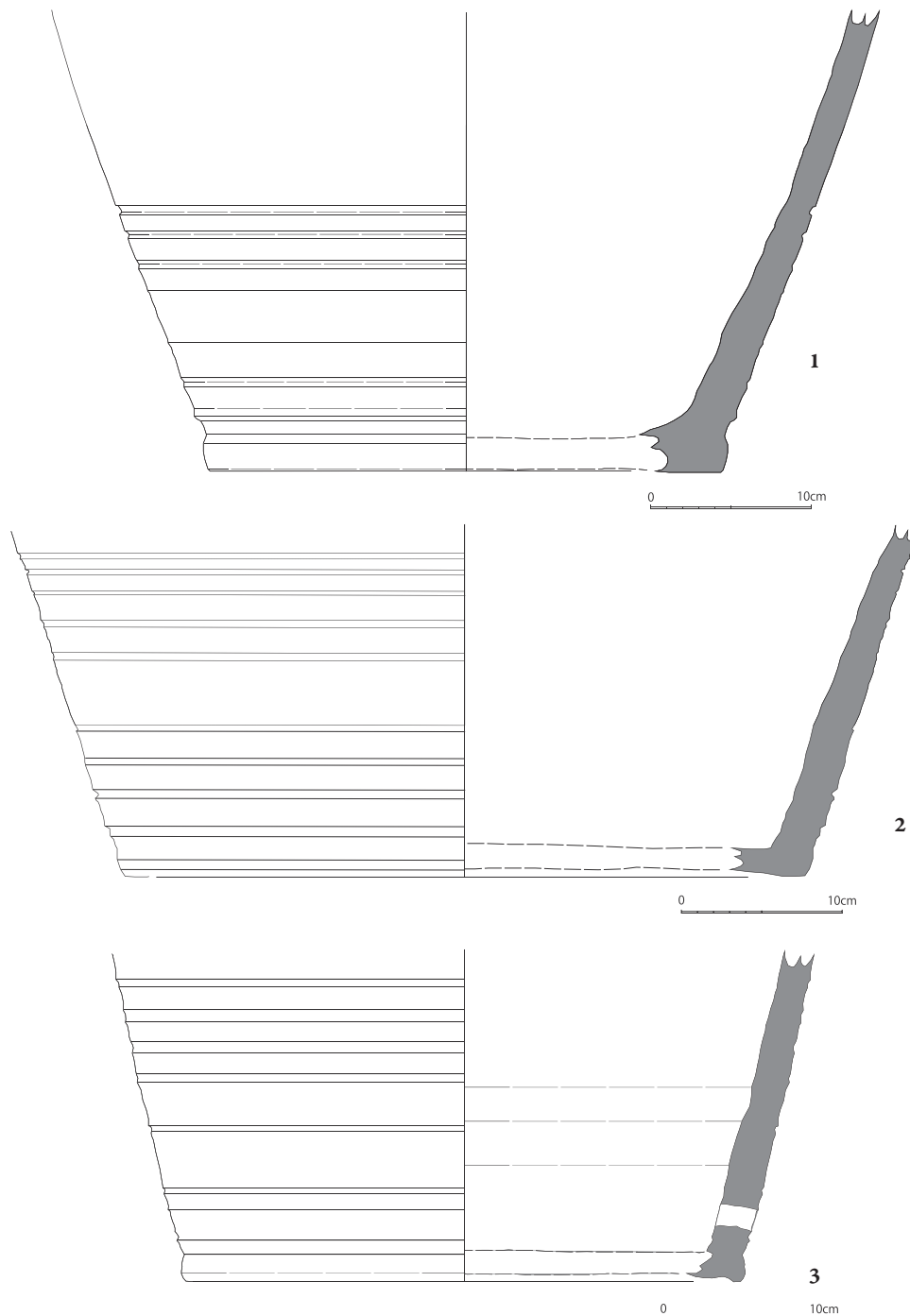


Fig. 28 Brown-Glazed Ware



Fig. 28-1



Fig. 28-2



Fig. 28-3

Fig. 29 Brown-Glazed Ware



Fig. 30 Brown-Glazed Ware from Ta Nei Temple

Unglazed ware (Fig. 31 and 32)

Stoneware of greyish clay without any glazing is categorized as unglazed ware. Wide-mouth jars (Figs. 31-1 to 3) were observed. They have a body rising from a relatively large base and have a stretched shoulder. Similar forms are observed in the products made in the Maenam Noi or the Ban Bang Pun (Suphanburi) kilns in central Thailand—although, those are dated to after 15th century. Fig.31-4 is a shallow basin which is something rarely observed in Khmer stoneware. Meanwhile, a slightly smaller wide-mouth jar (Fig.31-5) and basin (Fig.31-6) are often seen among Khmer wares.

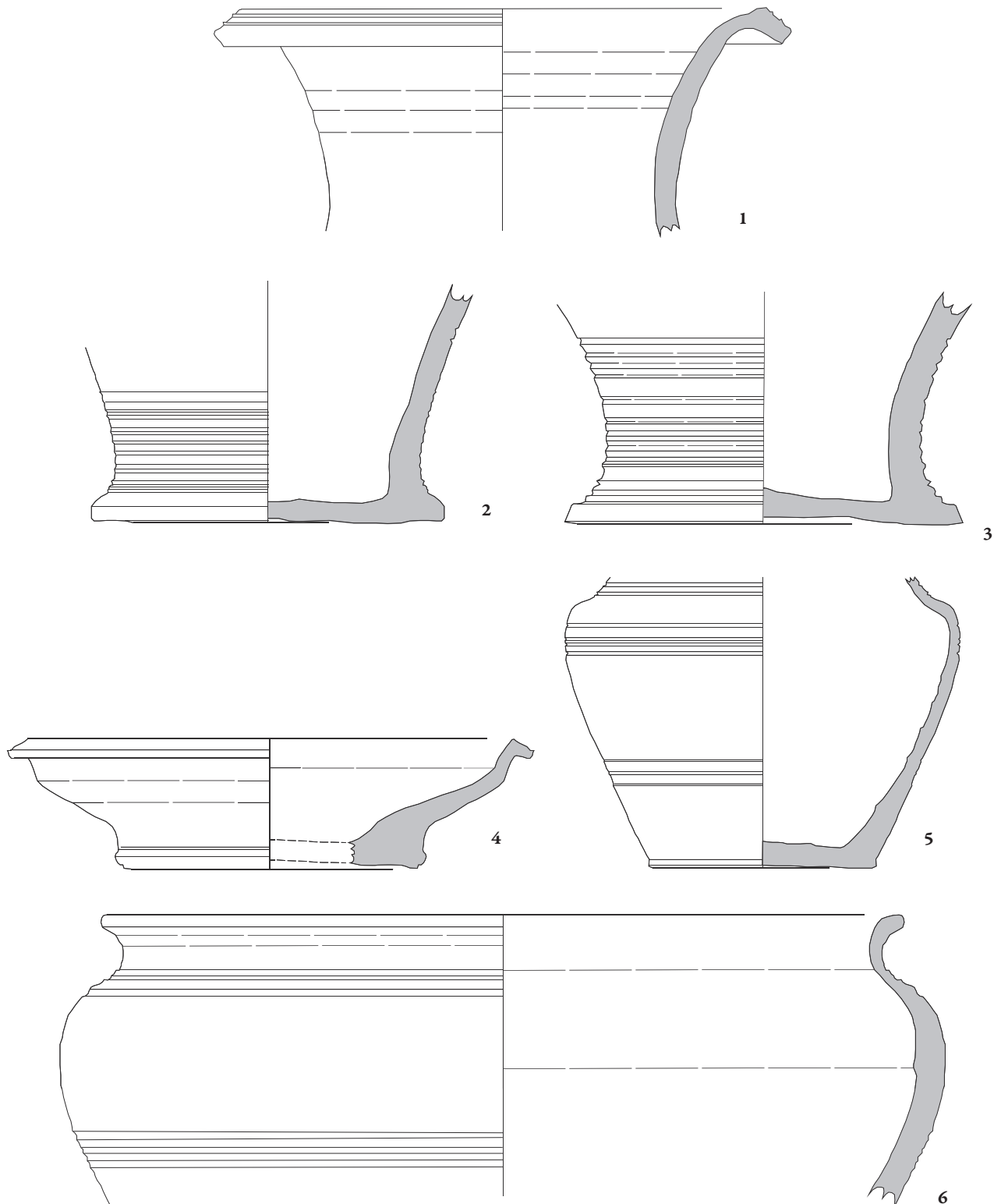


Fig. 31 Unglazed Ware

0 10cm



Fig. 31-5



Fig. 31-6

Fig. 32 Unglazed Ware

Unglazed ware with fine clay (Figs. 33 to 35)

Among the unglazed wares, there is a small number of fine-clay unglazed stoneware with unique decoration. Compared to brown-glazed and other unglazed stoneware, this type was carefully molded with refined whitey clay. Many of the shapes are similar to those of unglazed ceramics, but there are also unique shapes such as four-ear-lugged jars (Fig. 33-1) and bowls (Fig. 33-2).

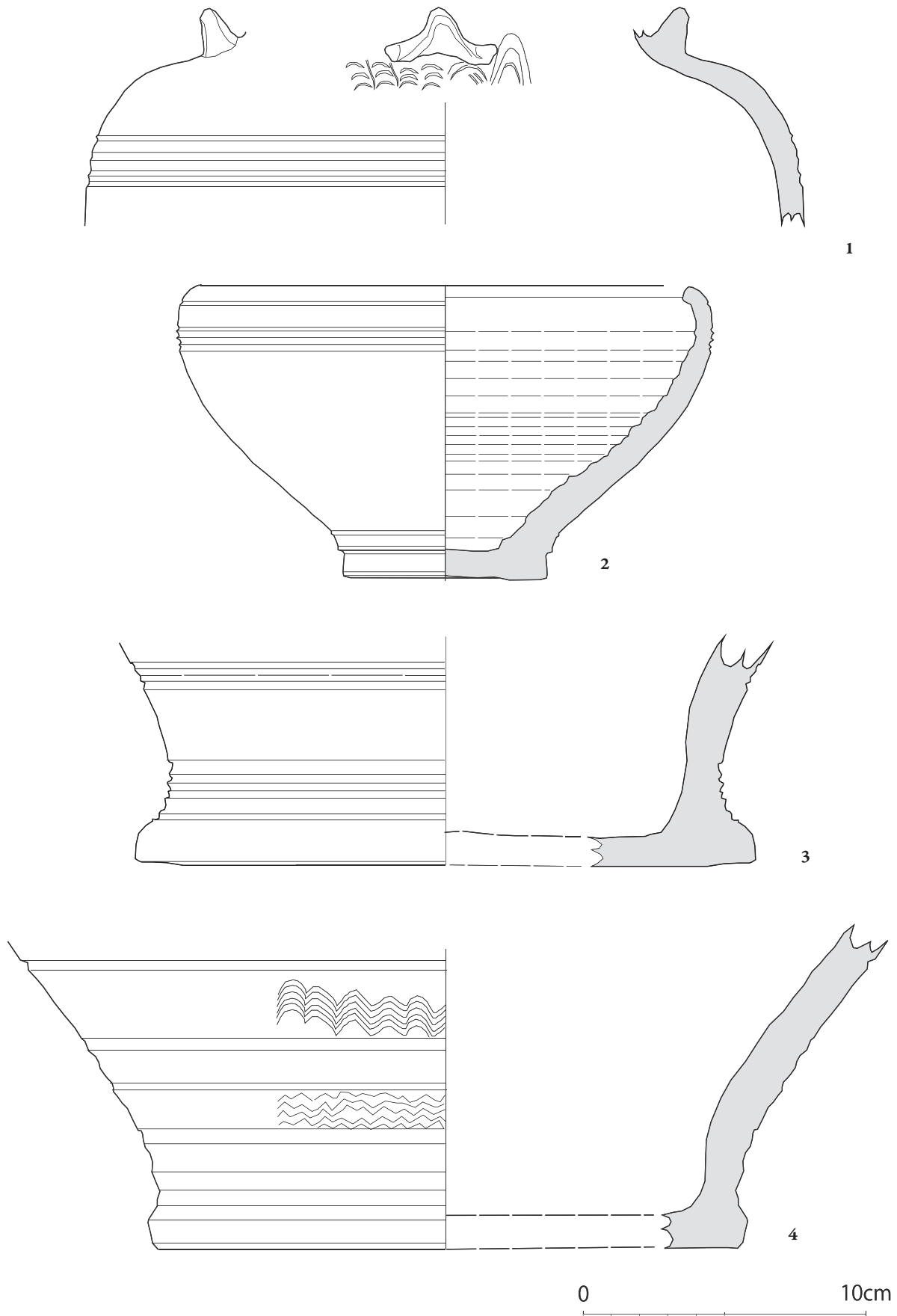


Fig. 33 Unglazed Ware with Fine Clay

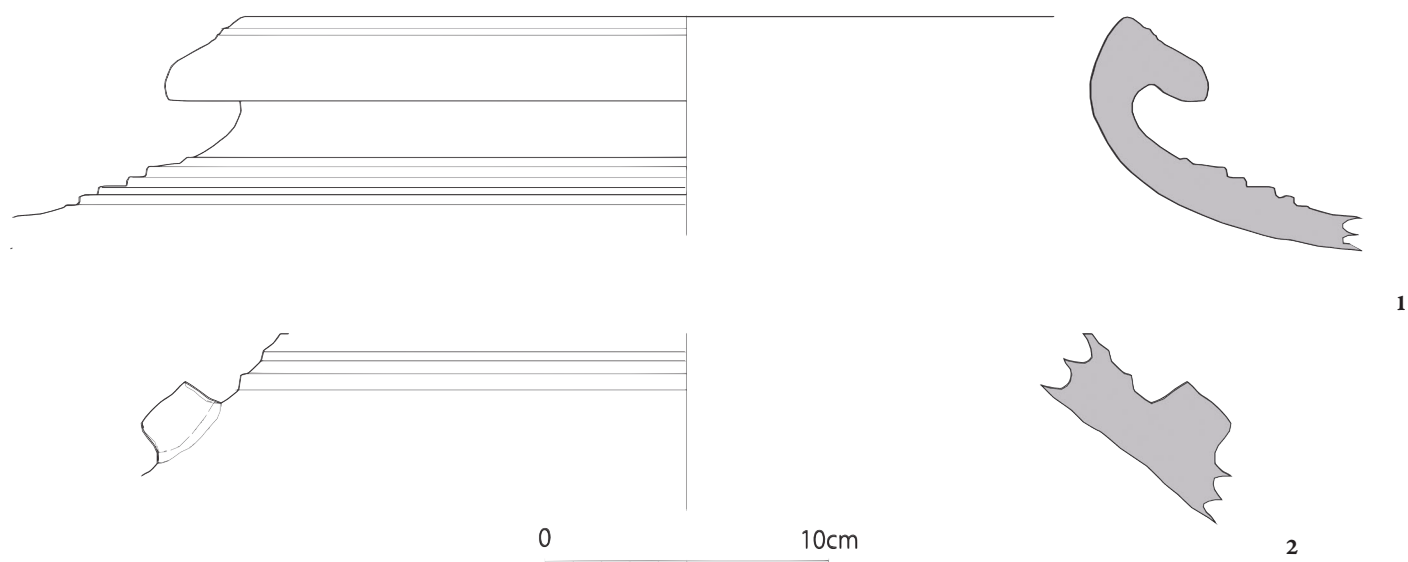


Fig. 33-2

Fig. 34 Unglazed Ware with Fine Clay



Fig. 33-4



Fig. 34-1

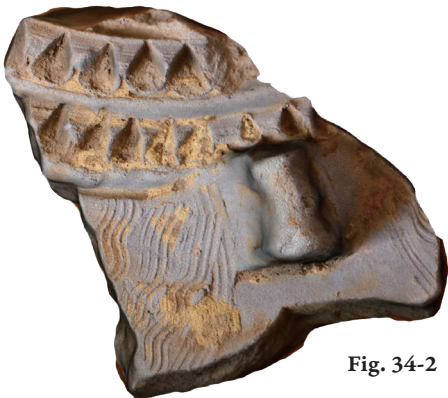


Fig. 34-2

Fig. 35 Unglazed Ware with Fine Clay

Animal Motifs (Fig. 36)

The zoomorphic container vessels, commonly with small and plain openings on the upper surface (the animal's back), are representative of premodern Khmer stoneware. However, no piece of a zoomorphic container was identified from Veal Kok Treas. Instead, animal figurines and jars with animal decoration were unearthed.

All three sherds were brown-glazed stone ware. Fig. 39-1 is a 5.2cm long miniature four-legged animal such as a dog or boar. Fig. 39-2 (8.5cm long) and Fig. 39-3(4.9cm long) are the heads of elephants. Elephant heads were often attached to the shoulder of wide mouth jars as a handle. In this case, the elephant's nose is arched to form the lug of a jar.



Fig. 36 Animal Motifs

Tiles (Fig. 37)

Two brown-glazed round tiles were identified. Fig. 42 is a fragment of the broad end of a round tile. This sherd is 17.8cm in width, 1.4cm thick, with a blackish-brown glaze on the convex side.



Fig. 37 Round Tile

4. C14 Dating

**Shigeru ITO, Masanori SATO, Masashi HIROTA, Hideki YAMAGATA,
Zaur LOMTATIDZE, Yukiko KIKUCHI, Yasuko KURONUMA**

Charcoal samples for radiocarbon dating were collected from the Veal Kok Treas Kiln in Cambodia. This report shows the result of radiocarbon dating done by Accelerator Mass Spectrometry (AMS) and the calibrated ages.

Materials and Methods

Table 1 shows the sample data and pretreatments done on the sample. Pretreatments for AMS measurements were performed at the laboratory of Paleo Labo Co., Ltd (Japan). and ^{14}C concentrations were measured by Paleo Labo AMS system (Compact AMS, NEC, 1.5SDH). The conventional ^{14}C age and the calibrated age were calculated after correcting the carbon isotopic fractionation.

Table 1 Sampling Data and Pretreatments

Lab No.	Sampling Area	Sample Type	Pretreatments
PLD-36690	Sample No.3 (Charcoal No.4)	Type: charcoal (Hopea-Shorea)	Ultrasonic cleaning
	Area: Trench No.5	Sampling position: outermost tree ring	Organic solvent treatment: Acetone
	Layer: II	Condition: dry	Acid-Alkali-Acid method
	Depth: 50-60cm from the surface		(HCl: 1.2N, NaOH: 1.0N, HCl: 1.2N)

Results

Table 2 shows the $\delta^{13}\text{C}$ value for the correction of isotope fractionation, conventional ^{14}C ages and calibrated age. YrBP – “year Before Present” means before 1950. The most commonly used convention in radiocarbon dating. “Present” referring to the year 1950 AD. $\pm 1\sigma$ error means that the conventional ^{14}C age is within the error range with 68.2% probability.

^{14}C ages are not equivalent to calendar ages because of the changes of ^{14}C concentrations in the atmosphere, so radiocarbon calibration is essential to convert ^{14}C ages to calendar ages. The calibration was performed using OxCal 4.3 (with the IntCal 13 calibration curve). The calibrated age was calculated by the probability method of OxCal program within 1σ (68.2%) confidence limits and 2σ (95.4%) confidence limits. The percentages in parentheses in Table 2 show the probability that the actual date lies within those ranges. Figure 1 shows the calibration results. The curves on the vertical axis in the figure show the probability distribution of ^{14}C ages (red), and the dual curves are the calibration curve (gray) and light blue curves are the IntCal13 calibration curves.

When we are dating a piece of wood or charcoal, we must know which part of tree the sample is taken from. Trees grow by the addition of annual rings. The inner part of a tree called heartwood is older than the outer part of the tree, called sapwood. Radiocarbon dating of sapwood gives a date near to the age of death of the tree. The ^{14}C age of inner tree rings gives older ages than the actual age of death of the tree (the “old wood effect”).

In the case of this charcoal sample from Veal Kok Treas Kiln, the outermost tree ring was measured which means that the measured age shown in this report is telling the age of death of the tree. The measured age was consistent with the presumed period of the kiln.

Table 2 ^{14}C ages and calibrated results

Lab No.	$\delta^{13}\text{C}(\text{‰})$	Conventional ^{14}C Age (unrounded)(yrBP $\pm 1\sigma$)	Conventional ^{14}C Age (rounded)(yrBP $\pm 1\sigma$)	Calibrated Age	
				1σ	2σ
PLD-36690	-28.08 ± 0.11	817 ± 19	815 ± 20	1216-1255 cal AD (68.2%)	1186-1264 cal AD (95.4%)

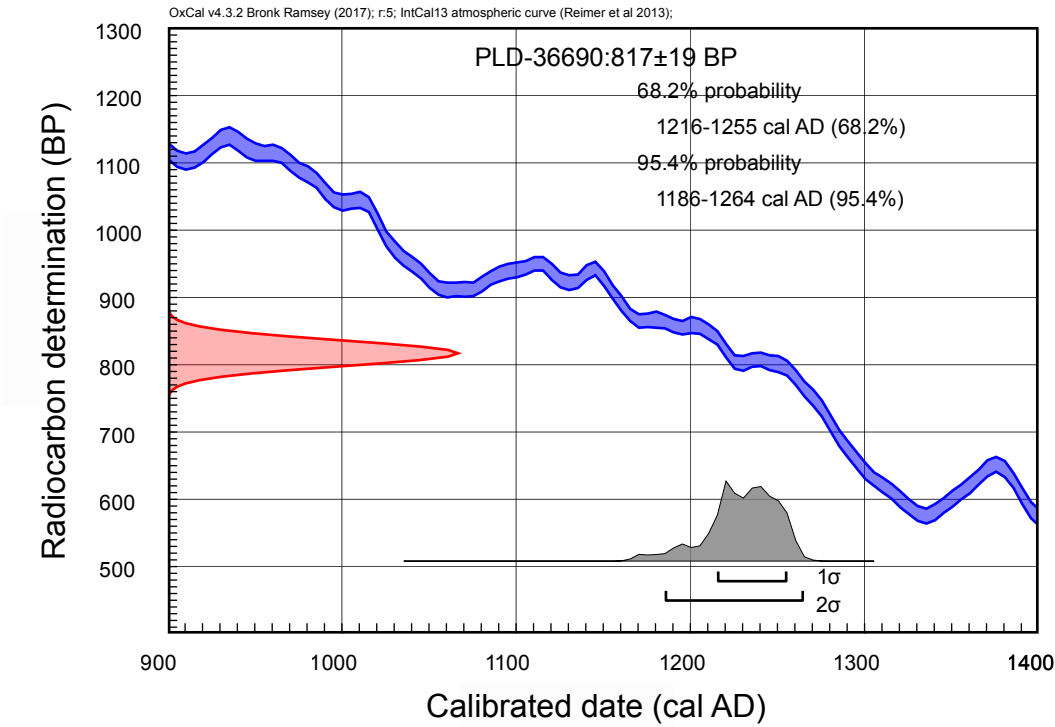


Chart 1 Calibration results

5. Identification of the Carbonized Wood

Yasuko KURONUMA

Charred wood samples were collected from Veal Kok Treas Kiln in Cambodia. This report shows the results of wood identification done on the charred wood samples.

Methods

Nine charred wood remains were collected from the Veal Kok Treas Kiln. The information on the samples is shown in Table 1.

Before identifying, the form of each sample was examined using a stereo microscope, remaining tree rings were counted and the remaining diameter was measured. For identification, the samples were split using a cutter to show the three sections, cross, tangential, and radial longitudinal, and fixed on a brazen stand with double-sided tape, applied with silver paste, and finally coated with gold. Observation and identification were done using a scanning electron microscope (SEM).

Results

The nine charred wood remains were all identified as Hopea-Shorea. The numbers of remaining tree rings were unknown because the annual ring boundaries were vague. No.1, No.2 and Nos.6–9 were broken pieces, the maximum residual diameter was 0.5–2.5cm. Nos.3–5 were split logs of residual half diameter 1.5–6.0cm. Table 1 shows the results. Brief descriptions of the taxa are as below.

(1) Hopea-Shorea (Dipterocarpaceae) Figs.38-40: 1-3 1a-1d (No.1), 2a-2d (No.2), 3a-3d (No.3), 4a-4d (No.4), 5a-5d (No.5), 6a-6d (No.6), 7a-7d (No.7), 8a-8d (No.8), 9a-9d (No.9)

Diffuse-porous wood with large-sized vessels solitary or in multiples of 2-3. Perforation plates simple. Axial canals in

Table 3 Results

small-size and long tangential lines. Axial parenchyma vasicentric or parenchyma aliform. Rays homocellular, 1-5 cells wide, fusiform.

No.	Trench	Depth (cm)	Date	Layer	Charcoal No.	Taxa	Form	Residual diameter (tangential/ radial)	Number of annual rings	Lab No.
1	5	40→50	2017.12.23	2	Charcoal No.1	Hopea - Shorea	Broken piece	1.0×1.5cm	?	-
2	5	50→60	2017.12.24	2	Charcoal No.3	Hopea - Shorea	Broken piece	1.0×1.5cm	?	-
3	5	50→60	2017.12.24	2	Charcoal No.4	Hopea - Shorea	split log	1.5cm (half diameter)	?	PLD-36690
4	5	50→60	2017.12.24	2	Charcoal No.5	Hopea - Shorea	split log	2.5cm (half diameter)	?	-
5	5	50→60	2017.12.24	2	Charcoal No.6	Hopea - Shorea	split log	6cm (half diameter)	?	-
6	5	60→70	2017.12.24	3	Charcoal No.7	Hopea - Shorea	Broken piece	1.3×1.5cm	?	-
7	5	-	2017.12.24	3	Charcoal inside Pot No.1	Hopea - Shorea	Broken piece	1.3×2.0cm	?	-
8	5	115	2017.12.25	4	-	Hopea - Shorea	Broken piece	0.8×2.0cm	?	-
9	5	107	2017.12.25	4	-	Hopea - Shorea	Broken piece	0.4×0.5cm	?	-

Remarks

The nine charred wood samples from Trench No.5 of the Veal Kok Treas Kiln were Hopea-Shorea.

Nos.3–5 were split logs. The residual half diameter of No.3 was 1.5cm, No.4 was 2.5cm, and No.5 was 6.0cm, which means that the diameter of No.3, No.4 and No.5 should have been around 3.0cm, 5.0cm, and 12.0cm. However, No.3 was lacking the pith though the outermost tree ring was remaining. No.4 and No.5 were lacking both the pith and the outermost tree ring which means the diameter should have been a little longer than 5.0cm and 12.0cm.

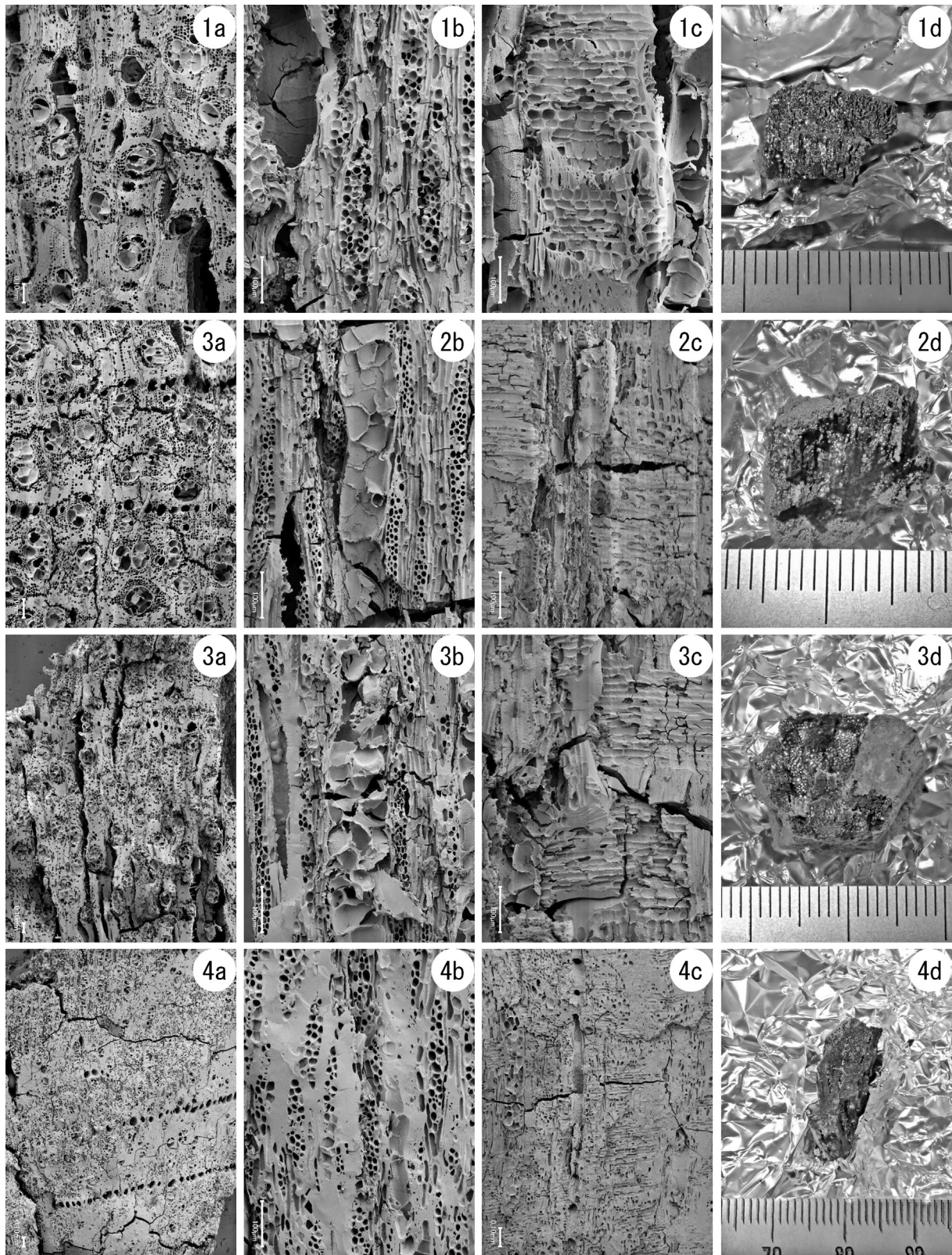


Fig.38 SEM photos and sample photos of the charred wood samples (1)

1a-1d. *Hopea - Shorea* (No.1) , 2a-2d. *Hopea - Shorea* (No.2) , 3a-3d. *Hopea - Shorea* (No.3) , 4a-4d. *Hopea - Shorea* (No.4)

a: cross section, b: tangential section, c: radial section, d: sample photo

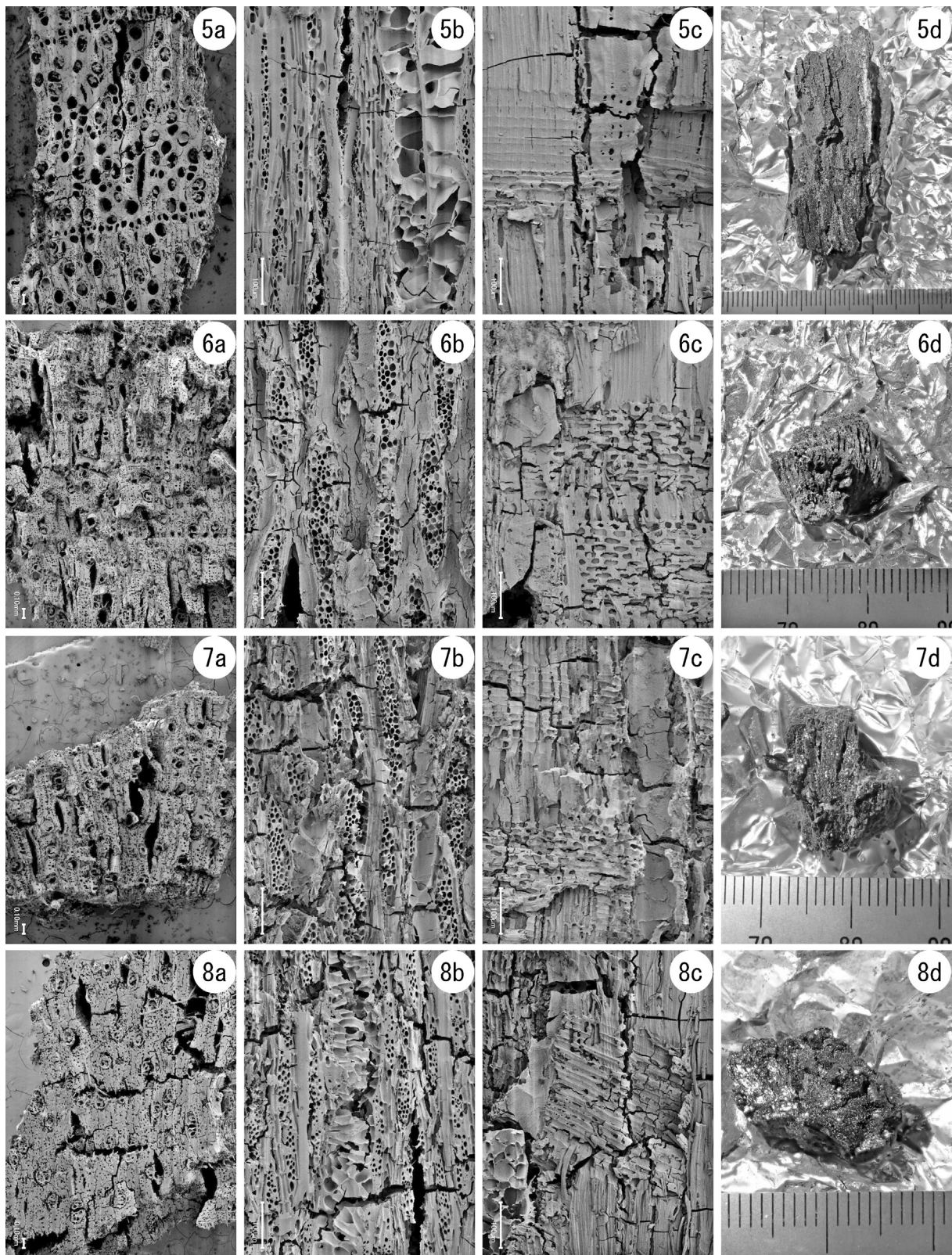


Fig.39 SEM photos and sample photos of the charred wood samples (2)

5a-5d. *Hopea – Shorea* (No.5) , 6a-6d. *Hopea – Shorea* (No.6) , 7a-7d. *Hopea – Shorea* (No.7) , 8a-8d. *Hopea – Shorea* (No.8)

a: cross section, b: tangential section, c: radial section, d: sample photo

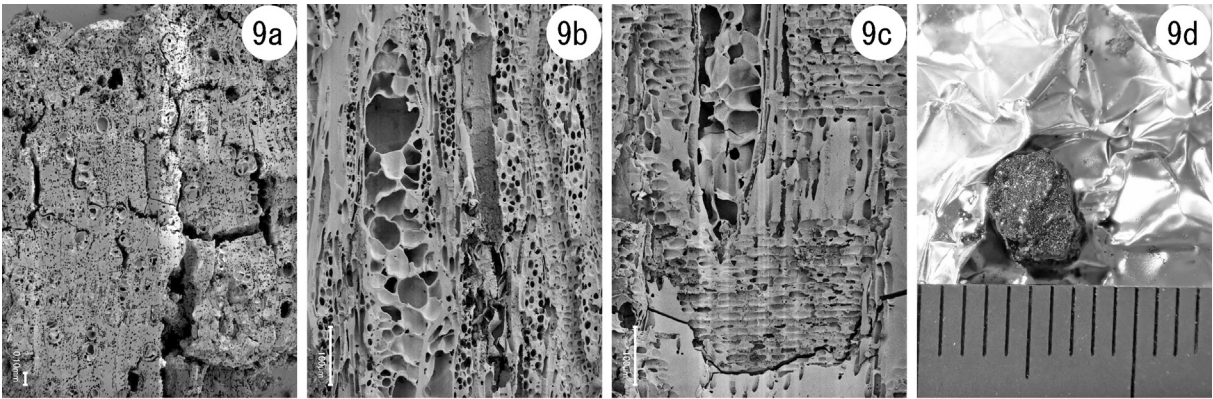


Fig. 40 SEM photos and sample photos of the charred wood samples (3)
9a-9d. *Hopea – Shorea* (No.9)
a: cross section, b: tangential section, c: radial section, d: sample photo

Conclusion

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The excavation of the Veal Kok Treas kiln#1—a part of the large-scale production center located east of the Angkor plain—shows a unique nature for brown-glazed stoneware production in the late Angkor period. In terms of a secondary firing trench, there were no trenches or any other features to put additional fuel during the firing in the ware chamber. This was also the case at Veal Svay. Our initial hypothesis (see Introduction) was that the Veal Svay kiln might be older than those at Torp Chey or the Chong Samrong (13th to 14th centuries), and thus its structure bears some resemblance to the older ash-glazed stoneware kilns in the Angkor area—date of ash-glazed stoneware kilns in Angkor being around the 10th to the 11th centuries— and, have no secondary fire trench. Although, a 14C date of the Veal Kok Treas kiln ranges from the late 12th to the late 13th centuries, the Veal Svay kiln dates to the late 13th to late 14th centuries (Nara National Research Institute for Cultural Properties 2017, 22), and the 14C dating conducted on the Torp Chey kiln shows dates from the 13th to 14th centuries (Ea 2016: 86). With reference to the present understanding of the date for Khmer brown-glazed stoneware—it is the 11th or 12th century to the 14th century. These dates do not support the idea that brown-glazed stoneware kilns, with the secondary firing trench (as at Torp Chey and Chong Samrong) was a later type of kiln, and neither that, the simple-structured kilns without the secondary firing trench (as at Veal Svay and Veal Kok Treas), were the prototype or transitional case from the ash-glazed type to the brown-glazed type kilns. Another explanation is needed.

We might illustrate the function of the secondary firing trench with a hypothesis concerning the purpose of production. If Torp Chey and Chong Samrong were specialized kilns used only for large-sized stoneware needing large inner space of the ware chamber for loading, then certain operating techniques might be required to maintain the appropriate condition of the ware chamber—apart from the question that ancient potters could control the draft by providing fuel to the ware chamber, not to the firebox. But are there any other interpretations for the secondary firing trench?

Further understanding of the secondary firing trench would be derived through detailed studies on the artifacts and the kiln structures in this area. Meanwhile, another discussion on the alternative question must be started. Besides the rare case of Veal Kok Treas, most Khmer stoneware kilns are rebuilt on older kilns, as seen in the Angkor area or arranged in parallel as in Northeast Thailand. According to the site reports for Torp Chey and the Chong Samrong, most of the earthen mounds remained available for future investigation, which means that these mounds were not fully investigated. Therefore, we need to examine the possibility that the secondary firing trench is a part of overlapped or parallel-built kilns. Further intensive studies of both the artifacts and kiln structure of these kilns will cast new light on these subject.

Regarding the artifacts, all of the miss-fired sherds from the mound and waste heap seem to belong to the excavated kiln because there were no older floors indicating any the reconstruction of the kiln. The basic repertory of the products—jar, basin, vat, roof tile and small animal figurines—are limited, though common to the surrounding kilns. B. P. Groslier claimed that the brown-glazed Khmer stoneware had become dominant after the late 11th century, and jars became major products after the 12th century (Groslier 1981: 27–29). While it has not been fully confirmed by post-civil war studies on the Angkor monuments, results of archaeological excavation at stoneware production centers in the late Angkor period seems to support his idea.

A notable brown-glazed stoneware item from this kiln is a jar with a side hole formed before firing. A similar example was found by research in previous literature. An unglazed jar with a hole in the base was excavated from an ash-glazed/unglazed stoneware kiln, the Tani kiln B4, and this hole was also created before firing.

Of course, the hole-on-the-body seems to have a different function to the hole-in-the-base. But in any case, a hole formed before firing suggests that these types of jars were produced for a special type of storage with limited uses. Moreover, the same type of jar was excavated from a temple in the Angkor area. During the archaeological investigation at Ta Nei temple conducted by the

APSARA and the Tokyo National Research Institute for Cultural Properties, a brown glazed stoneware jar with a side hole on the lower part was excavated. Due to the identical clay, decoration, glazing and holing, the jar excavated from Ta Nei temple is presumed to have been produced at either the Veal Kok Treas kiln or at least from the surrounding kilns.

As for productivity, the Veal Kok Treas kiln (kiln #1) seems to have operated for a short time and on a small-scale of production. Due to the short duration of the kiln, the date of the artifacts found from the site could be quite close to the date of the carbonized wood (fuel)– the late 12th to the late 13th centuries. The remark will provide a kind of chronological milestone for the future establishment of ceramic chronology in the late Angkor period.

In conclusion, the excavation of Veal Kok Treas kiln #1 has provided us with many insights into the pyrotechnological industry, including the stoneware kiln structure, products, fuel, date and other technical aspects of stoneware production. It shows the unique nature of the brown-glazed stoneware production of the Khmer and, further intensive investigation is required to understand the importance of this area as one of the largest production centers of Angkor. However, this area is in danger from site destruction due to rapid land development for mass-agriculture, and already, disappointingly, a significant number of kilns and kiln groups have completely disappeared despite the desperate efforts of local and foreign archaeologist to prevent the site destruction (Fig. 41). This recent situation in which non-monumental archaeological sites have been destroyed in an unregulated manner must not be overlooked.



Fig.41 Destroyed Kilns

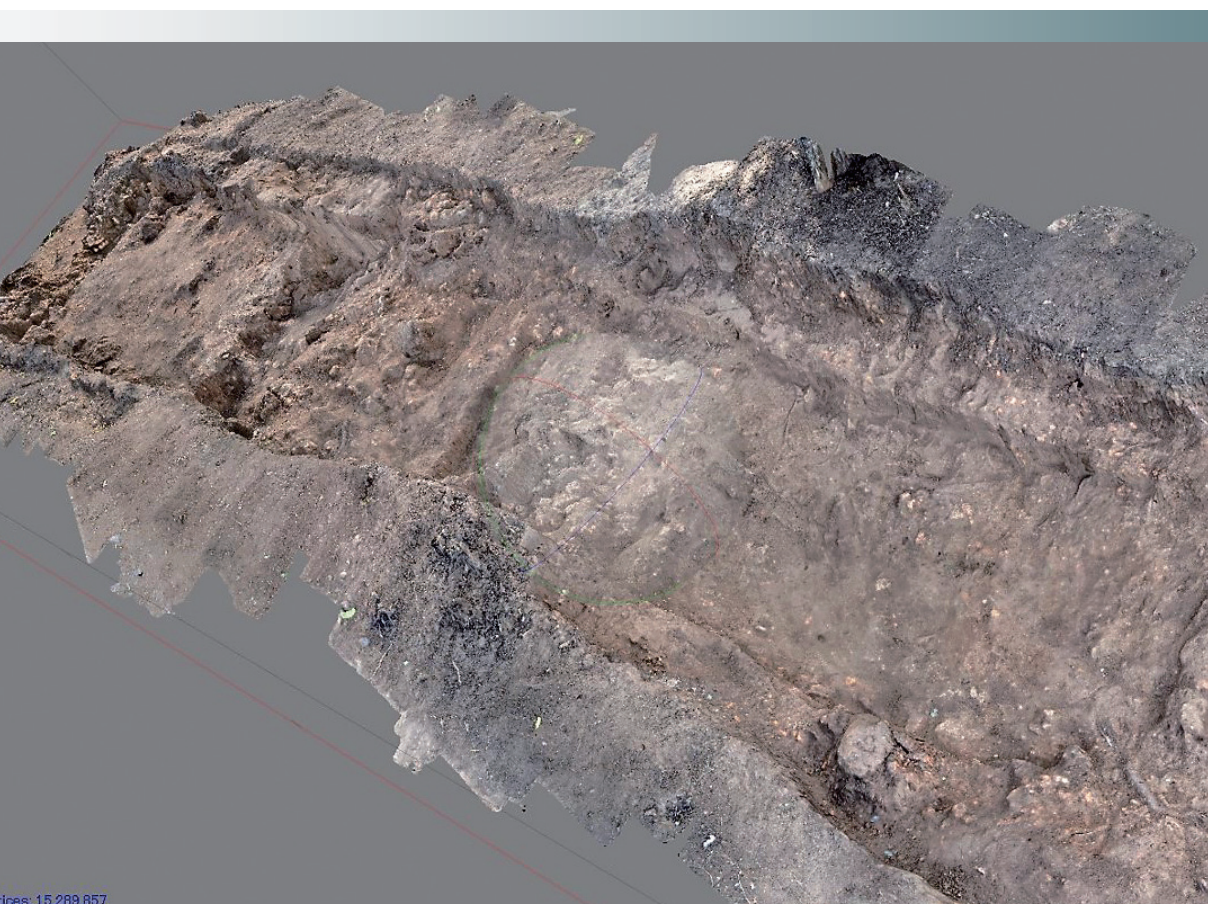
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The Veal Kok Treas Kilns I

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