2

Kilns in East Asia and Their Characteristics

Tomoko Nagatomo

Abstract: This essay discusses the introduction of kilns on the Korean peninsula and the Japanese archipelago, focusing on the differences in firing temperatures and distribution areas between 'flat' and 'tunnel' kilns. The flat kiln was first introduced in the Korean peninsula and originated from North China. Then, as the relationship between South China and the Korean Peninsula deepened, the tunnel kiln, a more advanced kiln that can fire higher, was introduced. There were three regions on the Korean peninsula at that time: the Midwest, the Southeast and the Southwest, and the differences of kiln style arose in these regions because of such differences as preceding societies and interaction with the state in South China. Furthermore, based on the examination results in the Korean peninsula, the earliest kilns in the Japanese archipelago were directly influenced by the kilns in the southwestern part of the Korean peninsula, but this did not form the basis of Japanese kilns. The kilns in the southeastern part of the Korean peninsula were introduced again and spread to Japan.

Keywords: flat kiln, tunnel kiln, firing temperature, southern China, northern China, Baekje and Mahan, Gaya and Silla, Korean peninsula, Japanese archipelago

Introduction

High-temperature firing in kilns was a highly advanced technology in the peripheral areas of China, and it was introduced into the Japanese archipelago from China via the Korean peninsula. In the regions where open-fired[1] pottery was used, the introduction of kilns enabled potters to make sophisticated tableware and storage equipment.

On the other hand, there is a wide variety of kilns in China, and the diffusion of kilns should be discussed in consideration of the diversity. In this paper, we will investigate the diffusion of kilns from China to the Korean peninsula and the Japanese archipelago, focusing on the kiln structure, after we comprehensively examined the kilns in China.

Incidentally, the first kiln-fired stoneware in Korea and Japan, which originated from China, was gray in color. Currently, gray stoneware has a unique name in each country, as follows: It is called *hui tao* in China, which simply means "gray stoneware". A layer of ash was applied to *hui tao* pottery, which was fired in high-temperature kilns of the Shang dynasty, resulting in a natural glazed gray finish. In Korea, gray pottery is called Wajil ware (low-fired stoneware) and Dojil ware (high-fired stoneware). Wajil ware appeared in the Proto-Three Kingdoms period (P-TK, first century BC to mid-third century), and Dojil ware appeared in the Korean Three Kingdoms period (KTK, late third century to seventh century). Japanese gray pottery is called Sue ware (stoneware), which appeared in the middle Kofun period (the end of the fourth century). Dojil ware and Sue ware sometimes bear a natural glaze.

[1] Open firing used in the absence of a permanent facility to fire pottery. There are various methods of open firing with different degrees of sealing in Southeast Asia. Some use a cover of rice straw; others use one of rice straw and mud. The latter can make more rigid pottery than normal open firing, but it is not a kiln.

2.1. Current issues

2.1.1. Sue ware and its kiln

Kilns were introduced into the Japanese archipelago at the end of the early Kofun period, the end of the fourth century. The Suemura kiln group (SKG) began to operate in this period; it was the largest long-term running kiln cluster from the Kofun to the Heian period. The study of Sue ware starts with the investigation of SKG, and has thus far shown great results.

At the beginning of Sue-ware studies, many researchers believed that the kiln-building technique spread from the SKG to the other local kilns (Tanabe 1971, 1981). However, when several early kilns were excavated in the Setouchi region and the coastal area of Osaka Bay, some researchers started to think that kilns were introduced and managed in various regions in the same early stage of SKG (Hashiguchi 1982, Saito 1983, Fujiwara 1992, Takesue 1993). And then, TG No. 232 kiln was discovered

in SKG, which is one of the oldest kilns in Japan (Okado eds. 1995, 1996). At present, the importance of SKG in the process of kiln development has resurfaced (Ueno 2002, Tanaka 2002, Hishida 2007, Nakatsuji 2013) due to the following facts: a) it contains some of the oldest kilns in Japan; b) it surpasses other kilns in scale and continuity; c) the presence of *futatsuki*, a small bowl with a lid that is the most common vessel type of Sue ware from the fifth century (Yamada 1998: 80).

There is no doubt that the Sue-ware kilns in Japan originated from the Korean peninsula. From comparing early Sue ware and Dojil wares, it is clear that the former was strongly influenced by the latter and the influence originated from the Gaya kingdom. However, there are some types of pots, such as wide-mouthed pots and wide-mouthed vessels with a small hole, among early Sue ware that compel some researchers to assume that early Sue ware was partly influenced by Baekje and Mahan ware (Sakai 1994, 2004). Regarding wide-mouthed vessels with a small hole, Nakakubo indicated that they were formed in Japan (Nakakubo 2017:108). However, there are few studies on the origin of the kiln itself. Among them, Ueno Kōzō presented the corpus of examples of the kiln in the Korean peninsula and insisted that the Deai kiln and TG 232 type kiln are similar to the ones in the Baekje and Mahan regions by emphasizing a planar form (Ueno 2017), but since the origin of early Sue ware was mainly in the Gaya region, the origin of Sue ware and that of the aforementioned kilns do not coincide.

2.1.2. Kilns in the Korean peninsula

In the P-TK period in Korea, the western region was known as Mahan, the eastern part as Jinhan, and the southeastern part as Byeonhan. Jinhan became Silla and Byeonhan became Gaya in the KTK period. The Mahan region is somewhat more complicated; Baekje formed in the present Seoul area and covered a peripheral area called Kyeongi. However, the southern part of Manhan did not become the territory of Baekje but continued to be called Mahan until the end of the sixth century.

New vessel shapes and techniques such as round bottoms and forming by paddle were introduced in the P-TK period. It was believed that Wajil ware in southeast Korea was formed by external influences from the stoneware of Lelang commandery (Shin 1982). In addition, the stoneware with a paddled pattern on the surface in central to southwest Korea was also formed in the second century with influence from Lelang stoneware (Park 1989). Furthermore, some researchers have presumed that Wajil ware was fired in a flat kiln (Yang 1984) and Dojil ware in a tunnel kiln because Dojil ware was fired at higher temperatures than Wajil ware (Takesue 1985, Shin 1986).

On the other hand, in the Baekje and Mahan regions, a large kiln group known as the Samryongri/Sansuri kilns, which began at the end of the P-TK period, has been excavated (Choi et al. 1986; Choi B. 1988). As a result, Choi Byeonghyeon estimated that kilns in the whole P-TK period were not flat kilns because Samryongri/Sansuri kilns have sloped floors (Choi 1992). Lee Seongju suggested that Wajil ware was influenced by the stoneware production technique of the Warring States period in China because the cord-paddling pattern was seen more often than the slanting lattice-paddling pattern[2] (Lee 1991). Also, he classified the kilns as dragon-shaped, round-shape, dome-shaped and rectangular-shape, and made them conform to Liu Zhenquin's classification (Liu 1982) based on the direction of the fire: updraft type, flatdraft type, semi-downdraft type, downdraft type. Lee Seongju argued that the kilns in the P-TK period resembled the round-shaped kiln of the flatdraft and semi-downdraft type in China. He concluded that it developed into a kiln in the Three Kingdoms period. He also believed that TK 73 of SKG in Japan succeeded the structure of the Samryongri/Sansuri kilns. As a result of Lee Seongju's study, it became a common view that the round-shaped kiln of the flatdraft and semi-downdraft type was introduced to the Korean peninsula and brought to the Japanese archipelago.

Research on kilns progressed in each region, such as Baekje and Mahan (Park 2001, Lee 2008, Jeong 2008, Choi 2010), Silla and Gaya (Kim 2004, Kim 2007). Five kilns per group appeared from the third to the fourth century in the Baekje and Mahan regions, but the number of grouped kilns increased from the end of the fifth century, especially in the southern area (Lee 2008). In addition, considering Oryangdong at Naju was the kiln site for firing jar-coffins (Choi et al. 2004, Yeon et al. 2011, Jeong 2012), peculiar developments in kiln-making were seen in Mahan region.

In the Silla region, a large and continuous kiln group consisting of more than 40 per group, such as Seongokdong, Hwasanri, Uksudong and Oksandong appeared in the latter half of the fourth century and reached their peak after the middle of the fifth century. As some of these were located around the royal capital of Silla (Ueno 2015), it is assumed that stoneware production was controlled by the regime (Yamamoto 2018). In contrast, no large kiln groups have been found in the Gaya region.

2.1.3. Issues with the regional diversity of kilns

Several issues can be identified from the above studies. First of all, the terms and contents of classification have still not been examined thoroughly enough. Secondly, an increase in kiln excavation shows the regional diversity of kilns in the Korean peninsula. However, when discussing

[2] The paddling technique to make round bottoms was new in the P-TK period. It was presumed that the technique was brought from the Lelang commandery, but there are several differences in the shape and type of stoneware. Therefore, Jeong Inseong explained that the short-necked jar fired by a kiln in the P-TK period originated from the Yan type stoneware in the early or middle Han dynasty. In short, he insisted that the short-necked jars were developed before the establishment of Lelang commandery (Jeong 2013). However, Takaku Kenji opposed to the idea judging from the parallel relationship between burials in Lelang commandery and those in South Korea (Takaku 2018). The beginning of the P-TK period seems not to date back many decades before the establishment of Lelang commandery.

the origin and development of kilns in the whole Korean peninsula, regional differences are not taken into account, and when discussing each region, comparisons with other regions are often not made. Kilns in the Japanese archipelago are said to have inherited the structure of Samryongri/Sansuri kilns in Baekje and Mahan but most early Sue ware came from the Gaya region. There is thus a contradiction in the origin of kilns and stoneware.

The number of excavation and research cases increased in China 37 years after the study of Liu Zhenqun (1982). Recently, Fukazawa Yoshiki compiled a corpus of Chinese kilns that used a slightly different classification system from Liu (Fukazawa 2011), emphasizing three-dimensional structures. The author and colleagues focused on the firing temperature of stoneware and are advancing research on the determination of the kiln type by this measure.

Therefore, in this article, the author will focus on the relationship between the kiln structure and firing temperature, while considering the lineages of kilns in the Korean peninsula and the Japanese archipelago and paying particular attention to regional differences in kilns on the Korean peninsula.

2.2. Kiln variety and firing temperature in China

2.2.1. Kiln structure

According to Fukazawa Yoshiki's (2011) study, kilns can be classified into two types by oven floor: the kiln with oven floor type (type I, chapter 1, section 1.3, Fig. 1.2) and the kiln without oven type (type II). Furthermore, type I is divided into two types: with fire-ways (type Ia, Fig. 1.2.1: 1) and without fire-ways (type Ib). Type II is also divided into two types by shape: a broad-short type[3] (type IIa, Fig. 1.2.1: 3) and a long-body kiln type (type IIb and IIc). The former's ratio of length to width is around 1:1, and the latter's ratio of these is from 2 to 16:1. In type IIa, as the end of a firing chamber is dug and changed into a firebox, usually, a step is seen. Type IIb is shaped round and its ratio of length to width is less than 5:1 (Fig.2.1: 2). Type IIc is shaped like a long oval and its ratio of length to width is 5 to 16:1 (Fig. 2.1: 4). Regarding the step of types IIb and IIc, there are two styles: with a step and without a step. In addition, there is a group that is a hybrid of the two previous types from the Spring and Autumn period to the Warring States period of north China; it shows the transition from type Ib to IIa in a particular region.

Firing chambers and firebox are vertically separated in kiln type I, while these are horizontally separated in kiln type II. In kiln type I, the firebox makes heated air that rises to the ceiling through the stoneware in the firing chamber. In kiln type II, heated air made in the firebox flows sideways to the flue on the opposite side of the firing chamber, through the pottery. Consequently, type II can make a stronger flow of fire and heat than type I.

[3] Beginning in the Western Zhou period, kilns started to have flues.

In the case of kiln type Ia, it is difficult to conduct the heat to the stoneware due to the narrow path of heat, but its kiln structure is solid. On the other hand, type Ib can easily conduct heat to the stoneware due to its wide path, but its structure is vulnerable. It turns out that there is a limit of quantity when firing stoneware in a type I kiln.

Kiln type II has a very small temperature gradient between the firebox and flue because of the short length of the firebox. In other words, it can fire stoneware at a uniform temperature. Kiln type IIa corresponds to the draft and round-shaped kilns of semi-downdraft type in previous studies. Kiln type IIc corresponds to the tunnel kiln. Since the strength of the flame depends on the difference in elevation between the firebox and the flue, in the case of the short firing chamber, we can observe the same degree of flame strength regardless of whether its bottom is flat or sloped. Regarding kiln type IIa, the slope of the firing chamber is related to the ease of stoneware placing but it can be said that it does not greatly affect the firing itself.

2.2.2. Period and distribution

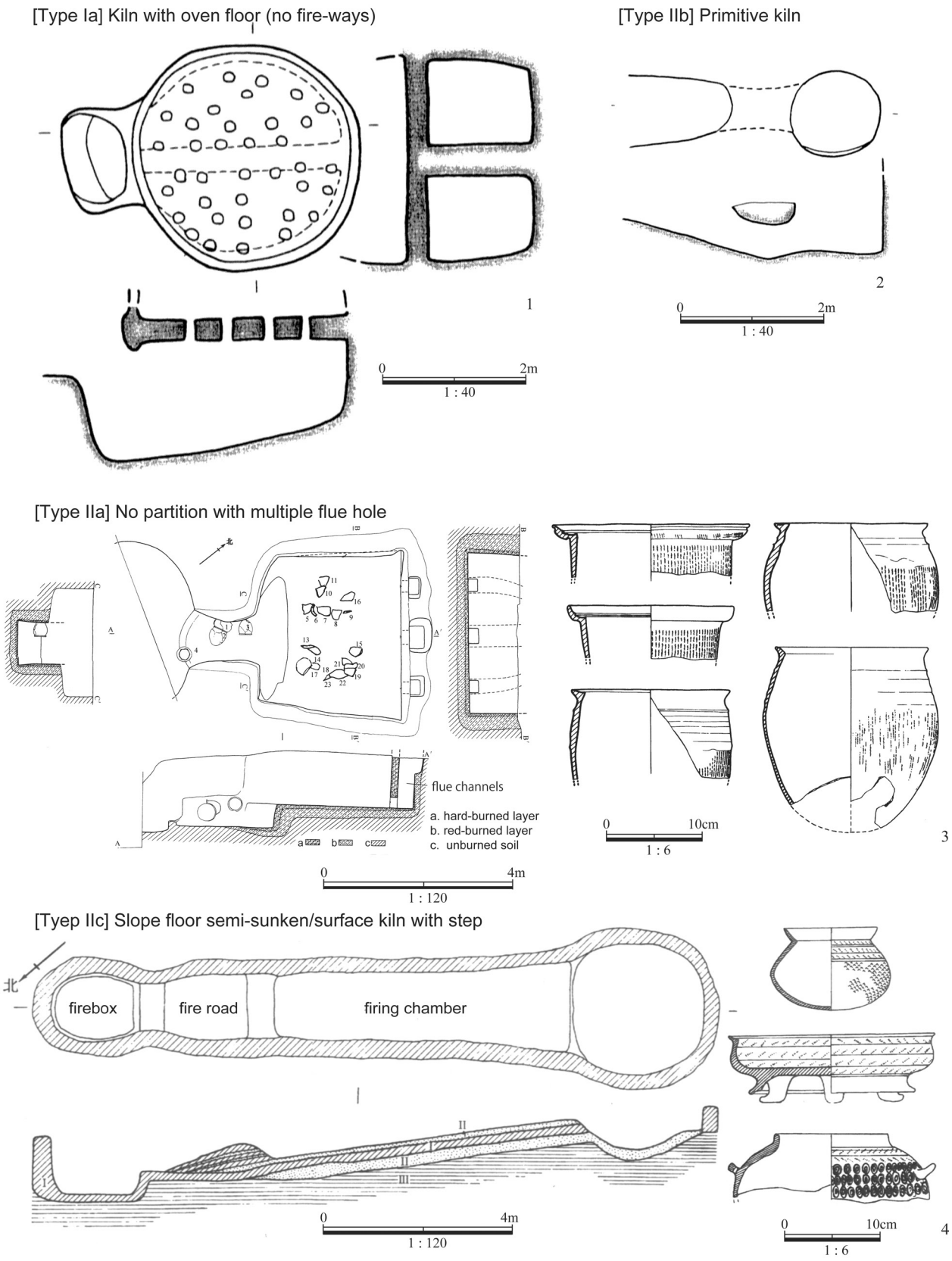
Kiln type I appeared in the middle Neolithic period and continued until around the Warring States period. Kiln type IIa appeared in the Western Zhou period and became more common when type I declined. Kiln types IIb and IIc appeared earlier than type IIa, and type IIb continued to be built from the Neolithic to the Bronze Age; type IIc was built from the Erlitou period until the Jin Dynasty (Fukazawa 2011).

Kiln type I was distributed in the upper and middle Yellow River basin. Kiln type IIa was mainly distributed in the middle Yellow River basin, but also distributed in the middle Yangtze River. Kiln type IIb was mostly seen in the middle Yellow River, and type IIc was distributed mainly in the lower Yangtze River and the coastal area of south China. Therefore, it is indisputable that type IIc kilns, with their long firing chambers, were developed only in the southern part of China. Fukazawa suggests that Sue-ware kilns in the Japanese archipelago originated from type IIc kilns in this area of China. Early kilns in China are very rare, and it is difficult to grasp the kiln structure at that time because most of the ones excavated had only the bottom and had lost their upper structure.

2.2.3. Correlation between firing temperature and kiln structure

When the firing temperature of kiln-fired stoneware was examined, the range was from about 800 up to nearly 1300 °C. There is a certain relationship between the structure of the kiln and the firing temperature[4] (Nagatomo 2017). Since the firing temperature can be analyzed from

[4] It is necessary to distinguish between experimental and actual high temperatures. In the case that a low-temperature operation is common in practice, there is the possibility that firing at a low temperature is preferred, to avoid the disadvantage of a high temperature, even if using higher temperatures is feasible.



1. Shanxi Yuanqu old city (after Archaeology Division of National Museum of Chinese History et al. 1997)
2. Hehan Xiawancun (after Fukazawa 2011) 3. Fangshan Nanzheng kiln No. 6 (after Cultural Relics Institute of Beijing 2008) ,
4. Guangdong Meihuacun Kiln (after Institute of Cultural Relics and Archaeology of Guangzhou 1998)

Figure 2.1. Kiln types in China.

stoneware, this method can compensate for the lack of preserved kilns from this period.

The author and research colleagues analyzed seven pieces of Yan state stoneware from the third century BC fired in a type IIa kiln (Fig. 2.1.3). Vitrification and amorphous clay minerals were observed with a polarizing microscope, but no minerals like mullite, which is formed over 1000 ℃, were found among them. This result showed this stoneware was fired at between 900 and 1000 ℃ (Table 2.1, Kanegae et al. 2017). Similar results were obtained for the firing temperature of Lelang stoneware excavated from the Korean peninsula and the Japanese archipelago (Cho 2006, Kanegae and Fukuda 2006). Additionally, although these are examples from the seventh to the tenth century in the Bohai period, examination with a polarizing microscope found that roof tiles were fired at between 800 and 900 ℃ or a slightly high temperature in a type II kiln at the Kraskino site in the Russian Far East (Zhushchikhovskaya and Nikitin 2017). These kilns were 12 in number and varied in size: about 1.0 to 1.7 m in width and 3.3 to 5.1 m in length, including firebox, firing chamber and flue.

Table 2.1. Firing temperature of pottery from the Pulandian Piziwo site

No.	period	form	FT
1	10th to 9th century BC	steamer	900-1000 ℃
2	10th to 9th century BC	steamer	900-1000 ℃
3	10th to 9th century BC	steamer	900-1000 ℃
4	4th to 3rd century BC	pot	900-1000 ℃
5	4th to 3rd century BC	pot	
6	4th to 3rd century BC	steamer	900-1000 ℃
7	4th to 3rd century BC	short-necked jar	900-1000 ℃
8	4th to 3rd century BC	short-necked jar	900-1000 ℃

On the other hand, in the lower Yangtze River, gray stoneware with natural glaze was fired at a high temperature in type IIc kilns. The natural glaze proves the use of the high temperature at which fuel-ash is melted. Ceramic was stably fired at a very high temperature, around 1200 ℃: 1160 to 1310 ℃ in the Later Han Dynasty, 1240 ℃ in the Three Kingdoms period, 1180 to 1300 ℃ in the Western Jin Dynasty, 1130 to 1270 ℃ in the Eastern Jin Dynasty, and 1190 ℃ in the Southern Dynasty (Table 2.2). The gray stoneware in the Meihuadun kiln from the late Spring and Autumn period (Fig. 2.2.) is estimated to have been fired at 1270 ℃, as was determined by the reheat thermal expansion coefficient measuring method (Institute of Cultural Relics and Archaeology of Guangzhou 1998), which shows that Type IIc kilns reached firing temperatures exceeding 1100 ℃ before the Warring States period.

Based on the comparison of the firing temperature in each kiln type, we may conclude that type IIc kilns can reach a higher temperature than Type IIa kilns. As the distance from the firebox to the flue of kiln type IIa is

Table 2.2. Firing temperature of ceramics in Zhejiang Province (based on Ye et al. 2008)

area	site or artifact	form	period	FT	note
Shangyu	Xiaoxianyun kiln	Celadon no-necked jar with paddling patterns	Eastern Han	1160±20	
Shangyu	Xiaoxianyun kiln	Celadon no-necked jar with paddling patterns	Eastern Han	1310±20	
Shangyu	Xiaoxianyun kiln	Celadon shallow bowl	Eastern Han	1270±20	
Shangyu	Xiaoxianyun kiln	Celadon straight-necked pot	Eastern Han	1260±20	
Shangyu	Zhangzishan kiln	Black-glazed ceramic	Eastern Han	1220±20	
Shangyu	Zhangzishan kiln	Black-glazed ceramic	Eastern Han	1200±20	
Shangyu	Zhangzishan kiln	Black-glazed ceramic	Eastern Han	1240±20	
Shangyu	Zhangzishan kiln	Celadon bowl	Three Kingdoms	1240±20	
Shangyu	Longquan tang burial	Celadon	Western Jin	1300±20	made in Yue kiln
Shangyu	Longquan tang burial	Celadon	Western Jin	1180±20	made in Yue kiln
Shangyu	celadon	Celadon	Western Jin	1220±20	
Shaoxing	Western Jin burial	Celadon jar with four handles	Eastern Jin	1270±20	made in Yue kiln
Deqing	Dequin kiln	Black-glazed ceramic	Eastern Jin	1150±20	
Yuhang	Yuhang kiln	Black-glazed ceramic	Eastern Jin	1130±20	
Jinhua	Jinhua Wùzhōu kiln	Celadon	Eastern Jin	1180±20	
Shangyu	Zhangzishan kiln	Celadon small bowl	Souhern Dynasty	1190±20	

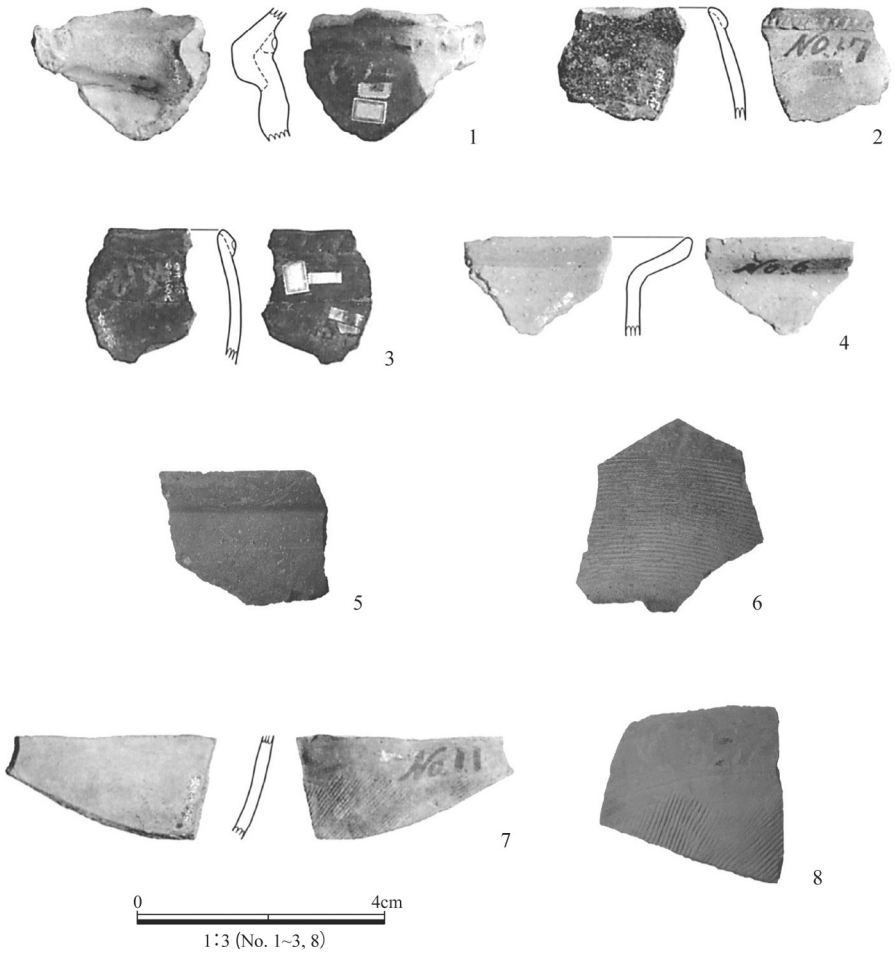


Figure 2.2. Analyzed pottery from the Pulandian Piziwo site (Kanegae et al. 2017).

short, the temperature gradient of these is not large. In other words, heat can easily escape from the kiln via the flue. In contrast, as type IIc kilns have longer firing chambers, the temperature gradient is larger. As a result, the flame and heat flow become strong, and the maximum firing temperature tends to increase in the firing chamber because heat can stay there for a long time.

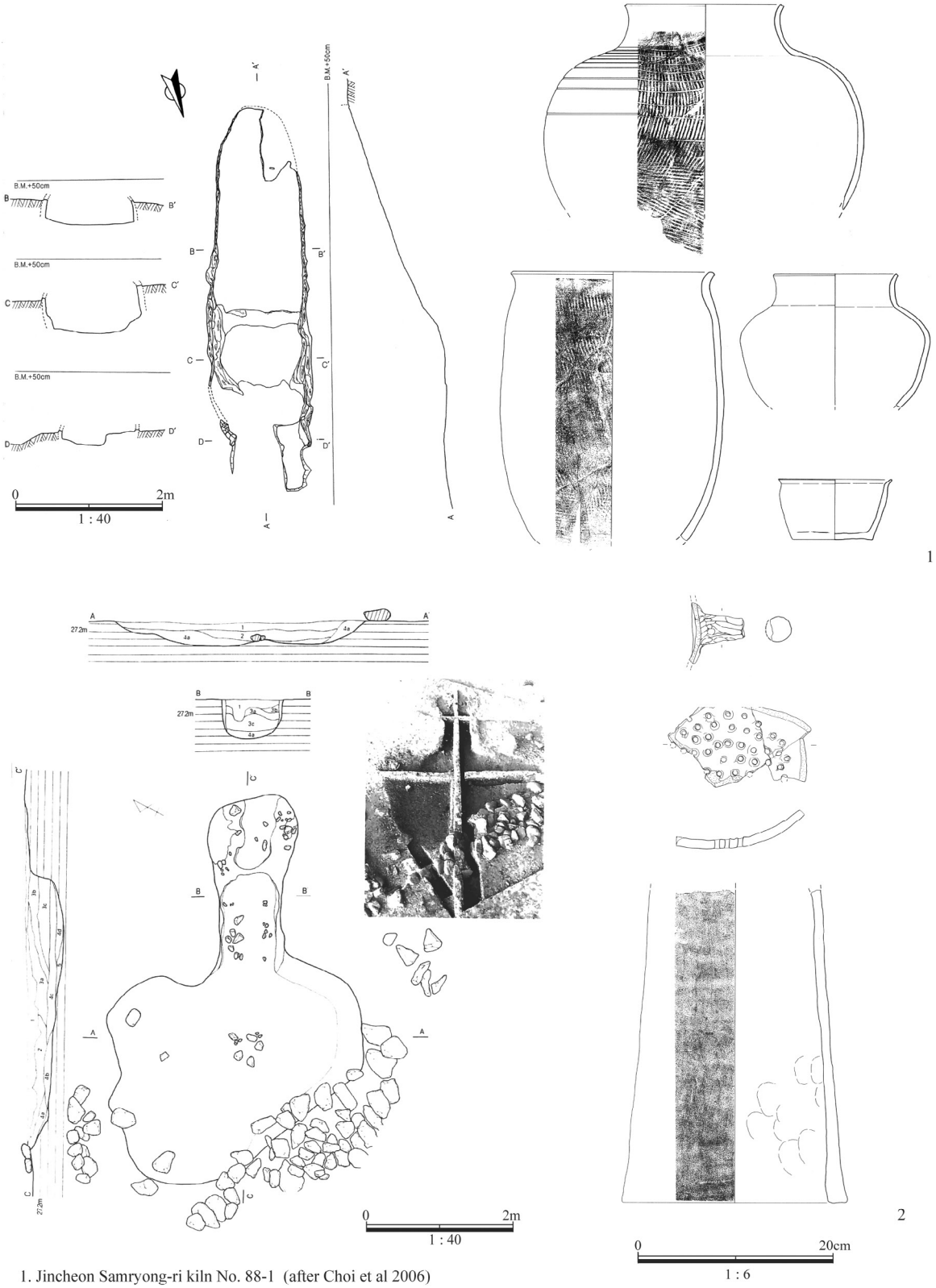
2.3. Kilns in South Korea

2.3.1. Early kiln and stoneware

Kiln-like remains have been found dating from the Bronze Age onward (Kang 2005). They are round or ditch-like, and their bottom face was often burnt, or a certain amount of stoneware sherds were found. However, it is difficult to regard these remains as kilns due to the lack of decisive evidence; the upper structures and burnt side walls have not survived, and stoneware found there does not have a rigid body. After all, it was not until the P-TK period that sure examples of kilns were found. Moreover, grouped kilns of more than ten per group have been found at the Samryongri/Sansuri kilns (Choi et al. 2006).

The Samsuri/Samryongri kilns continuously operated from the third to the fourth century, and they correspond to a transitional time from the P-TK to the KTK period in the Baekje and Mahan regions. These kilns are characterized by a deep firebox and have steps between the firing chamber and the firebox (Fig. 2.3: 1). The bottom of the firing chamber has a short slope. This conforms to the IIc type of kiln. Most of the stoneware found nearby was short-necked jars; the others were deep pots and steamers. According to the report on the Samryongri/Sansuri site kilns, the kilns were divided into five stages, and tray-shaped stoneware appeared starting in the fifth stage. However, there are no examples of pieces with sharp concave-sectioned lines and vessels with three legs, such as those found in Pungnap fortress. It is possible that the stoneware shapes found at the Samryongri/Sansuri site kilns were influenced by Baekje stoneware at the final stage, but these are typologically different from the examples from the Pungnap fortress and Mongchon fortress in central Baekje. The other characteristic of Samryongri/Sansuri site kilns is that they manufactured a blast tube for forging iron and provisioned the Seokjangri iron-making site (Nagatomo 2008).

Kilns were found in the Hwanseongdong site in the Gyeongju area of Jinhan region; this site was known as the iron production site (Fig. 2.3: 2). Although most of the firing chamber of the kilns did not remain, there are steps



1. Jincheon Samryong-ri kiln No. 88-1 (after Choi et al 2006)
2. Gyeongju Hwanseong-dong No. Na-13. (after Lee et al 2000)

Figure 2.3. Kilns in the Korean peninsula (1).

between it and the firebox. One of them was reported as a type IIa kiln: a draft kiln (Lee et al. 2000). Takesue Junichi insisted that this kiln was used for firing the clay core for casting ironware (Takesue 2002), but no clay core has been found at the kilns.

Made in the Jinhan and Byeonhan areas, Wajil ware has a variety of colors: light gray, light brown, white[5] (Society for

[5] The term "Wajil ware" was often used to refer to the stoneware with loosed reduction firing (Terai 2017); some researchers call the kiln-fired

Korean Archaeology 2013). Some unique types are seen, such as a jar with a pair of horn-shaped handles, jars with no necks, and short-necked jars with paddling pattern. In late stages of Wajil ware, the rate of types of pottery with short legs attached to round bottoms increased, such as small, wide-mouthed dishes with short legs and jars with short legs.

On the other hand, in the Baekje and Mahan regions, the findings consisted of rigid plane-stoneware, stoneware with paddling pattern, fired oxidation firing or reduction firing, and dark gray stoneware (Park Sunbal 2003). It is believed that the dark gray stoneware appeared under the influence of Lelang stoneware from the middle stage, which divided the P-TK period into three, besides stoneware with paddling pattern appeared at the same stage. Rigid plane-stoneware was composed of a deep pot, a cover and a bowl, which are characterized by a flat bottom and outward-opened rim. In addition, hand-strokes for smoothing the surface were observed on the lower body of this stoneware. Rigid plane-stoneware originated from a previous local culture. Stoneware with paddling patterns comprises a deep pot, a long oval-shaped pot, a steamer and a bowl. These have a round bottom or a flat bottom without hand-strokes on the lower body.

Stoneware in the P-TK period was diverse in each area, but an important point is that all the pieces have the common feature of a round bottom made by paddling. Judging from the observation of the paddling pattern on the round bottom, these were at one stage formed in a cylindrical shape. Next, the body was inflated by the paddling method, and then the bottom was reformed as round. By the paddling method, the walls of the stoneware are tightened and transformed at once. Therefore, the time required to make stoneware with the paddling pattern became shorter than for rigid plane-stoneware, which was made by piling up clay bands while adjusting the body shape to ensure there were no gaps. In short, the technique of making stoneware greatly changed in P-TK period (Nagatomo 2010). Since stoneware bodies became rigid, these were fired by kiln, even when the kilns themselves have not been found. It can be said that these new types of stoneware were accepted along with the introduction of kiln building technology.

2.3.2. Kilns of the Three Kingdoms period

Most of the kilns in the Baekje and Mahan regions are type IIc, with a step between the firing chamber and the firebox. The ratios of length to width of almost all the firing chambers is around 2:1, and the fireboxes are short. Some of the kilns are wider, more than 3 m. In the southern tip of the Mahan region, a kiln with part of its ceiling remaining was found at the Gunkok-ri site from the fourth century (Fig. 2.4: 1, Mokpo University Museum 1989). It is oval and short. The kiln has a slight step between the firing chamber and the firebox, and the bottom of the firing chamber has a gentle slope. Most of the other kilns in the Mahan region have a step and their firing chamber's length is two to three times their width. In the sixth century, kiln type IIa, with a nearly flat firing chamber and a high step between the firing chamber and the firebox, reappeared as a kiln for firing tiles. Since the Jeongamri site in the Baekje region has a new structure in which the fuel hole is made on the side and there are three flues, it is found that Kiln type IIa was introduced again as a new renewal style.

In the Gaya region, kilns of the fourth century were found, such as at the Myosari, Ugeori and Yeochori sites. They have a long, narrow shape with no step between the firing chamber and the firebox: a typical type IIc kiln. The firebox of the kiln is nearly horizontal and connects to the steeply sloping firing chamber in Yeochori section A (Fig. 2.4: 2). And then, the new shape of kiln appeared, in which both sides of the firing chamber are rounded and bulge out slightly, but the back wall rises vertically. However, these kilns consistently have no steps (Yamamoto 2018), and the maximum width of the firing chamber was 2 m or less. No wide-shaped kilns have been found.

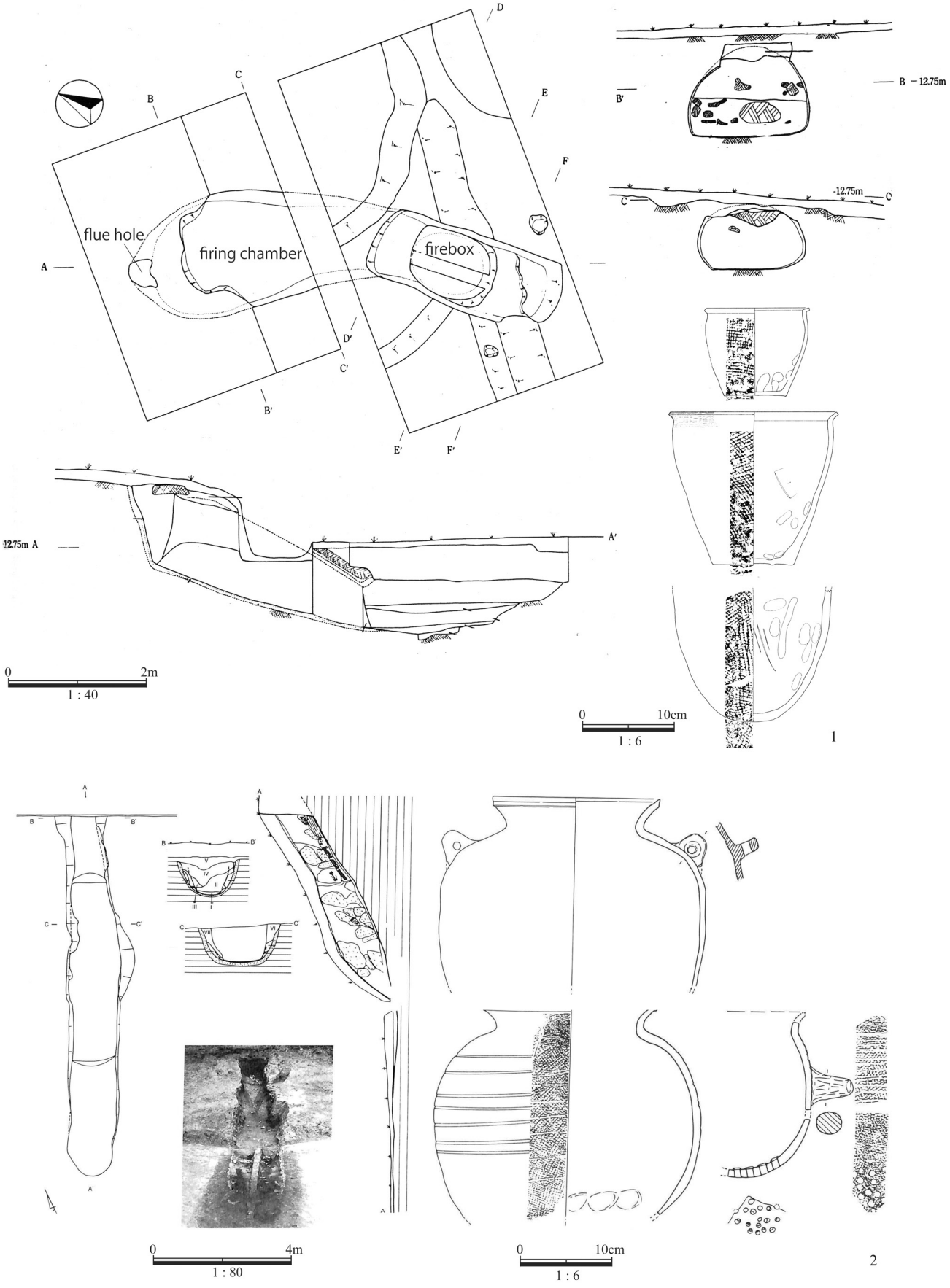
The proportion of tableware came to increase rapidly in Baekje, Silla and Gaya during the P-TK period. Shallow bowls and dish-like tableware appeared in Baekje. These vessels often had three legs attached, which is like the Chinese style. In addition, some patterns were drawn on the upper body of jars with short, straight necks and black jars with a polished surface from the KTK period. Baekje interacted with the Southern Dynasty of China and imported celadon jars with chicken-headed spout and large urns. The appearance of black jars with a polished surface reminds us of the relationship with porcelain in the Jiangnan area of central China. The rapid change in the composition of vessels from the P-TK period to the early Baekje period is closely related to the influence of Chinese stoneware.

On the other hand, the composition of Silla stoneware also changed significantly. The number of cups with a leg increased, and the ratio of tableware increased. Regional-style stoneware decorated using comb-shaped tools appeared, and large stands were also made. In Silla and Gaye, the custom of using a large amount of stoneware as burial goods began, which mainly consisted of tableware like cups with a leg. In contrast, the amount of stoneware used in graves is small in Baekje. It should be considered that the difference in demand for stoneware affected the improvement and enlargement of kilns involved in mass production.

2.3.3. Transition of firing temperature

The firing temperature of stoneware in the Baekje and Mahan area was analyzed by Cho Daeyeon (Cho 2006),

stoneware in the Baekje and Mahan regions "Wajil ware" (Kameda 2008, Terai 2017, Nakakubo 2017). However, in Korean archeology, it is common to use this term to refer only to stoneware in the Jinhan and Byeonhan regions in the P-TK period (Society for Korean Archaeology 2013). This paper will follow this usage.



1. Henam Gungokri Kiln (after Mokpo University Museum 1989), 2. Changnyeong Yeochori (after National Jinju Museum 1992)

Figure 2.4. Kilns in the Korean peninsula (2).

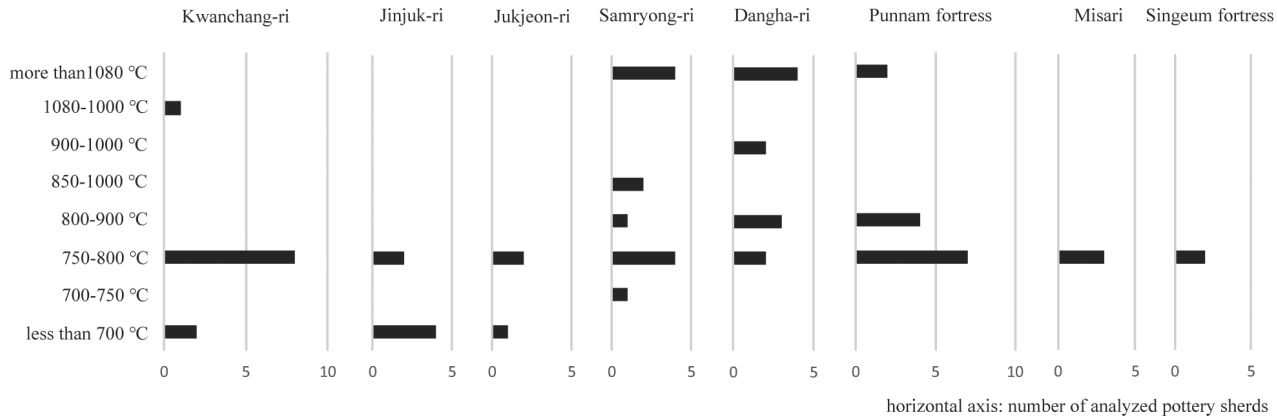


Figure 2.5. Results of the firing-temperature analysis for pottery in the Korean peninsula (based on Cho 2006).

and Fig. 2.5 shows the result. Regarding the stoneware of the Kwanchang-ri site in the Bronze Age, one sherd of stoneware was fired at around 1000 ℃ and two sherds were fired below 700 ℃. However, most of the stoneware was fired at the maximum firing temperature of 750 to 800 ℃. Examples from the Jinjuk-ri and Jukjeon-ri sites also showed the low firing temperature: below 800 ℃.

In the third to fourth centuries, a lot of stoneware was fired at high temperatures, over 1080 ℃, as in the Samryongri kiln. However, it should be noted that the frequency of stoneware fired at 800 to 1000 ℃ also increased, and a certain amount of stoneware was fired at 700 to 800 ℃. Also, in Pungnap fortress in central Baekje, there were examples fired at a high temperature of more than 1080 ℃, but the rate of stoneware fired at around 700 to 900 ℃ was high. Since Pungnap fortress is a residential area, it had a higher percentage of open-fired cooking stoneware than the Samryongri kiln site. Therefore, there was more stoneware fired at a low temperature in Pungnap fortress than in the Samryongri kiln. In the Misa-ri and Singeum fortresses, there were examples fired at around 700 to 800 ℃.

Based on the above, the stoneware was fired at a temperature of 800 ℃ or lower by the open firing in the Bronze Age. From the P-TK to the KTK period, stoneware fired at a temperature of over 1080 ℃ appeared. However, as most of the stoneware was fired at 700 to 1000 ℃ even after the introduction of kilns, it seems to have taken a long time to acquire the skill to fire in kilns at high temperatures.

Lee Seongju believes that the production of early Dojil ware starting in the middle of the third century parallels the late Wajil ware (Lee 2005). As mentioned above, he assumed that Wajil ware was fired in type IIc kilns. Although the firing temperature of Wajil ware sometimes went up to 1000 ℃, most of these were reduction-fired at a low temperature of 800 ℃ or lower. In contrast, the firing temperature of Dojil ware was around 1200 ℃. In the Silla and Gaya regions, the firing temperature increased gradually over time.

2.3.4. Change and development of kilns

In the P-TK period, kilns were built with a step between the firebox and the firing chamber across the regions. The kiln in Hwangsong-dong has such a step, although the firing chamber is as yet unrevealed; the Samryongri/Sansuri kilns have a deep firebox and a short firing chamber although they are type IIc kilns. It can be said that the former corresponds to kiln type IIa and the latter is kiln type IIc improved from kiln type IIa. This estimation agrees with the examination of stoneware firing temperature.

While the feature of a step between the firebox and the firing chamber was maintained even after the fourth century in the Baekje and Mahan regions, the type IIc kiln became the norm, considering that the firebox became slightly longer and the sloped bottom of the firing chamber appeared. Given the drastic change in the composition of stoneware including the vessel with three legs influenced by Chinese stoneware and the fact that a lot of celadon made in the Jiangnan area were acquired during this period, it is difficult to determine the change of kilns by internal changes. It is appropriate to consider the influence from the type II kilns in the Jiangnan area of Central China.

On the other hand, in kilns in the Gaya region from the fourth century onward, there was no step between the firebox and the firing chamber. At that time, the firing chamber changed from near horizontal to a strongly sloped shape to improve fire and heat flow. In other words, the bottoms of the firing chambers became bow-shaped (Ueno 2015). Moreover, kilns with a total length of more than 10 m appeared. Unlike kilns in Baekje, the complete style of the type IIc kiln was adopted in the Gaya region. It can be said that type IIc kilns in the Gaya region do not represent an improved kiln on the basis of the former one, type IIa.

From the early third century and later, 20 melting furnaces for casting iron were found at the Hwangsongdong site, and the refining of iron was also conducted there. With the prevalence of ironware, the presence of the Silla

and Gaya region became larger in East Asia due to its rich iron resources. It has been found that opportunities of interaction with southern dynasties increased via intermediate areas. Incidentally, the rise of iron-making in the Silla and Gaya regions was reorganized at the end of the first century. From that period onward, a lot of potash glass made from India to southern China was brought to the southern part of the Korean peninsula (Nakamura 2015). There is a possibility that new kiln techniques were introduced from southern China after the end of the first century, but they have not been found. At present, as sure examples of type IIc kilns appeared from the latter half of the third century to the fourth century, this was brought about by the beginning of the interaction with the Southern dynasty at the time of the establishment of Baekje.

The step between the firebox and the firing chamber is the most notable difference between the Baekje-Mahan region and the Silla-Gaya region. Although there are type IIc kilns with a step in China, it would be easier to understand the influence of the former type IIa kilns rather than to assume different kiln types were introduced to Baekje and Silla-Gaya. Therefore, in the southern part of the Korean peninsula, after the kilns appeared at the time around the establishment of Lelang commandery, they were newly affected by the Jiangnan area in China. In short, under the influence of multiple kiln types in China, kilns in the Korean peninsula appeared and changed.

2.4. Origin and features of kilns in the Japanese archipelago

2.4.1. Earliest kilns

Many researchers consider the Deai kiln in the city Kobe, located at the western end of Kinki area, the earliest in Japan. Although the firing chamber is mostly lost, it was short and had a step between it and the deep firebox (Fig. 2.6: 1). The commonality with kilns in the Mahan region has been pointed out from the shape of the kiln (Kameda 1989, 2008). The clay of ceramics excavated from the Deai kiln is similar to that of the P-TK period, and the firing temperature is estimated to be not very high.

The ceramics comprise such kinds as a short-necked jar, a dish-like vessel and a steamer. As both tableware and the storage container were found at the Deai kiln, it is different from the early kilns of SKG, which mainly produced storage containers. In the studies of stoneware at the Deai kiln, the similarity of the stoneware of the Mahan region has been pointed out (Kameda 2008). Among these, Terai Makoto limited the origin to the region to the Hoseo area of the northern Mahan region based on the rim shape of the short-necked jar (Terai 2017). The steamer has a straight mouth and round holes in the flat bottom (Kameda 1989). Based on examination of the shape features, the origin of the steamer from the Deai kiln originated in the western area of the Gaya region to Mahan. However, the absence of cups with a high leg and the presence of dish-like vessels shows that the stoneware at the Deai kiln most likely originated from the Mahan region. Besides, the earliest kiln in Samryongri, kiln No. 88-1, is earlier than the Deai kiln, since the steamer of the former has a round bottom with smaller holes (Fig. 2.3).

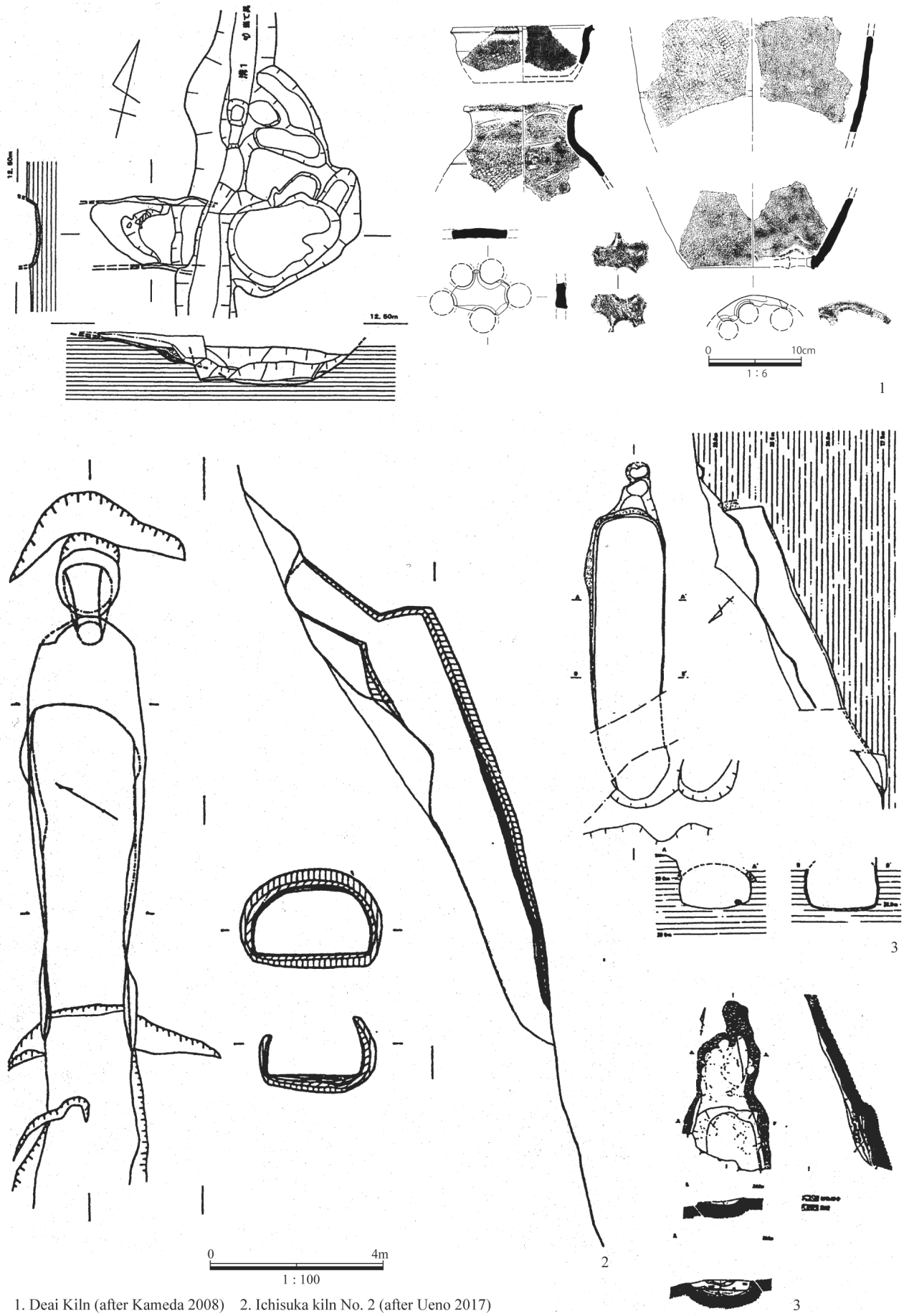
2.4.2. Early kilns and SKG

The confirmation of a certain number of kilns started during the period of TG 232 in SKG with such kilns as the Asakura kiln and Iyashiki kiln in the Kyushu area, West Bank kiln of Mitani-Saburoike in the Shikoku area, Okugatani kiln in the Setouchi area, and SKG, Suita No. 32 Kiln, Ichisuka No. 2 Kiln in Kinki area. In addition, the presence of kilns is assumed in the southern and western end of the Kinki area because of the distribution of the characteristic early Sue ware (Nakatsuji 2013). The distribution of kilns shows that kilns were introduced along the inner sea corridor from northern Kyushu to Osaka Bay.

As briefly mentioned in section 2.2, Ueno Kozo considered the southern Mahan area a possible origin place of Japanese kilns. He emphasized that early kilns in Japan have a small and linear planar shape, despite the difference in the presence or absence of a step between the firebox and the firing chamber (Ueno 2010, 2017). Fujiwara Manabu compared the kilns in the southern Korean peninsula from the late fourth to early fifth century with those in the Japanese archipelago (Fujiwara 1992). In consideration of the shape and size of the Samryongri/Sansuri site kilns, he found kilns in the southern Korean peninsula to be 4 to 15 m in length, 1.3 to 3.0 m in depth, and 10° to 30° in incline. Also, the vertical location of kiln-building was classified as underground, semi-underground and aboveground. Furthermore, Fujiwara determined that kilns were introduced to the Japanese archipelago when a huge, narrow kiln was formed in the Korean peninsula. Referring to these studies, let us begin our examination of the early kilns in Japan based on the previous analysis in this chapter.

The possibility of a step between the firing chamber and the firebox in the Iyashiki Kiln has been pointed out (Fujiwara 1992), but other than that the early kilns in the Japanese archipelago have no step. The firing chamber remained in Suita No. 32 kiln and Ichisuka No. 2 kiln. They are type IIc kilns, which have a slightly long firebox and a round flue (Figs. 2.6: 2–5). Besides these examples, most of the kilns in the period of TG 232 in SKG do not have a step. This fact shows that the early kilns in Japan were not descended from the kilns in Mahan and Baekje but were descended from kilns in the Gaya region. It was pointed out that the early Sue ware is similar to the stoneware of the Gaya region, such as that of the Haman, Changwon, Gimhae area. Since the early Sue ware has the quality and color of the body fired at high temperature in a reducing atmosphere, it can be understood that it was fired by a consummated type IIc kiln from the beginning of the introduction.

Incidentally, the amount of stoneware fired by oxidation firing that was distributed in the Korean peninsula,



1. Deai Kiln (after Kameda 2008) 2. Ichisuka kiln No. 2 (after Ueno 2017)
3. Iyashiki Kiln (after Ueno 2017) 4. Okugatani Kiln (after Ueno 2017)

Figure 2.6. Early kilns in the Japanese archipelago.

including cooking utensils such as a steamer and a deep pot, increased in settlements without kilns such as the Nagahara and Shitomiyakita sites in the Kinki area starting in the fifth century. Based on the characteristics of the steamer, it is obviously related to the Baekje and Mahan regions (Terai 2016). It seems that specialists from the Baekje and Mahan regions introduced other new technologies, along with kilns, to the Japanese islands.

2.5. Conclusion: Spread of kilns in East Asia

As the author examined above, the diversity in the peripheral areas around China is closely related to the regional differences of kiln types in China, which can be roughly divided into north China along the Yellow River and central

China along the Yangtze River. In north China, updraft kilns appeared first, and then flat kilns (type Iia) appeared in the Warring States period. In central China, tunnel kilns (type Iic) appeared around the Erlitou period and continued for a long time through the Qin and Han dynasties.

Kilns appeared earlier in Northern China, but were difficult to fire stably at high temperatures (more than 1000 ℃), judging from the firing quality of the stoneware and structure of the kiln. Low-temperature kiln firing was adopted instead of open-field firing in order to adapt to the cold climate, in which firing temperatures do not rise easily, and the limited forest resources. On the other hand, central China is warm and humid. People could fire stoneware by open firing with a stable temperature from 800 to 900℃, but kilns started to be used for high-temperature firing in order to obtain more rigid stoneware. As a result, celadon was created there.

In the Qin and Han dynasties, a flat kiln of short-wide style (type Iia) was widely used in the Yan state area, which is adjacent to the Korean peninsula, just before the kiln and its technology were introduced to the Korean peninsula. Considering that Wajil ware was fired at a low temperature

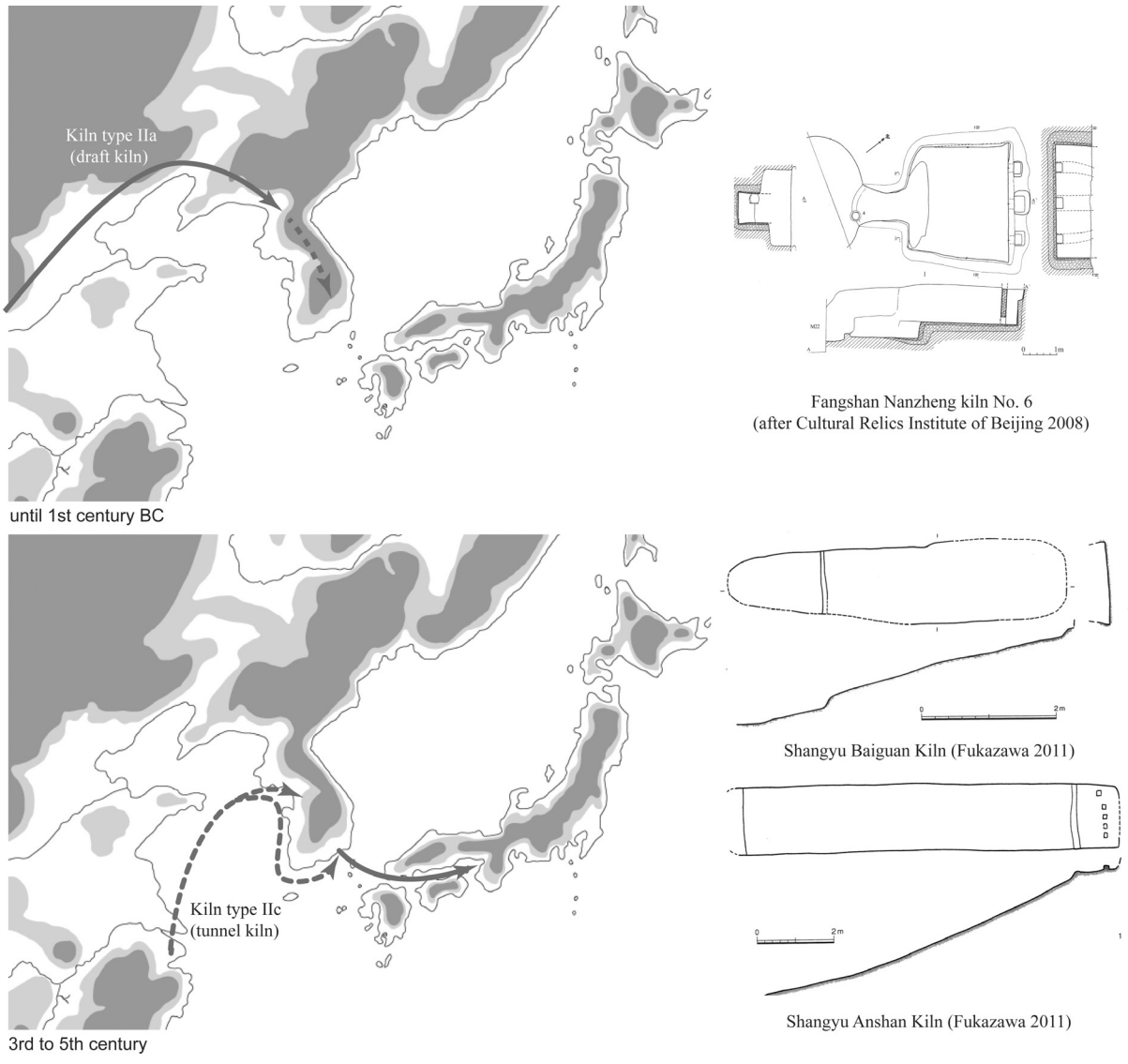


Figure 2.7. Spread of the two types of kiln.

(under 1000 ℃) according to the analysis of the clay (Kanegae and Fukuda 2006), there is a high possibility that the flat kiln was introduced to the Korean peninsula from the neighboring area.

With the arrival of the technique and structure of the tunnel kiln of long-body type Iic in the KTK period, people who were already using kilns of the former style succeeded in improving them or accepting the new style. Kilns were built on the slope and had a long firing chamber to improve flame flow. As a result, the maximum temperature of firing became higher than 1000 ℃ and stoneware came to have a more rigid body. However, the structure of kilns was not uniform and had great regional differences. The broad-short style with a step between firing chamber and firebox was maintained in the Baekje and Mahan regions, while kilns were changed to tunnel types without a step in the Gaya and Silla regions. It is significant that kilns were introduced to the Korean peninsula twice, in different periods (Figs. 2.7).

The Deai kiln, which was the earliest kiln in the Japanese archipelago, was influenced by kilns in the Baekje and Mahan region, but it was short-lived. In the period of the TG 232 kiln of SKG, the kiln and its technology were introduced in the range from the northern Kyushu area to Osaka Bay by sea again. The style of kilns was strongly influenced by kilns in the Gaya region, which is a narrow-long tunnel kiln.

The introduction of kilns and their attendant techniques is always related to political interaction in East Asia. The first spread was the spread of flat kilns through technological diffusion at the time of the establishment of the Lepang commandery. In the second spread, of tunnel kilns, Baekje began to build a stronger relationship with the state of the Southern dynasty in China against a northern rival, Goguryo. Also, in the case of the Japanese archipelago, there were conflicts among Japan, Silla, Gaya and Goguryo, which was pushing southward. It can be said that the introduction and development of kilns was complicated in combination with the activation of interaction, the change of trade networks, and international competition.

Acknowledgements

I would like to thank Prof. Zheng Jianming for showing me around the kilns in China, Prof. LEE Sungjoo for comments on my presentation in Korea, Prof. Daisuke Nakamura for many discussions and Prof. Yoshiki Fukazawa for many suggestions.

References

CHO, Daeyeon, 2006. *Crafting the State: analytical approaches to ceramics technology and exchange from the Bronze Age to Baekche period in Korea*, Doctoral thesis at the Department of Archaeology, University of Sheffield.

CHOI, Byeonghyun, 1988. Baekje Kiln sites in Chungbuk Jincheon area. *Kiln site research in Baekje period*, 33–94. [崔秉鉉「忠北鎮川地域百済土器窯址群」『百済時代의 窯址研究』].

CHOI, Byeonghyun, 1992. *Study of Silla Tumulus*. Iljisa. [崔秉鉉『新羅古墳研究』].

CHOI, Byeonghyun, HAN Sugji, 1986. Report on the excavation of Jincheon Samryong-ri & Sansu-ri, *Report on the excavation of cultural sites along the highway of the central area*. [崔秉鉉・韓淑姫「鎮川 三龍里遺跡発掘調査 報告」『中部高速道路文化遺跡発掘調査報告書』].

CHOI, Byeonghyeon, KIM Geunwan, RYU Kijung, KIM Geuntae, 2006. *Pottery kiln sites at Samryong-ri & Sansu-ri, Jincheon-gun*. Central Museum, Hannam University, Daejeon. [崔秉鉉, 金根完, 柳基正, 金根秦『鎮川 三龍里・山水里土器窯址群』]

CHOI Gyeonghwan, 2010. An Examination of Baekje Pottery Kilns from the Geum River Basin. *The Journal of the Korean Archaeological Society.* 76: 61–96. [崔卿煥「錦江流域 百濟土器窯址의 構造와 生産体制에 대한 一研究」『韓國考古學報』]

CHOI Gyeonghwan, Lee jeongho, Park Cheolwon, Lee Sujin, 2004. *Report on the excavation of Oryangdong kiln site*. Moppo University Museum and Dongshin University Museum, Moppo. [崔卿煥・李正鎬・朴喆元・李秀珍『五良洞窯遺跡』].

FUJIWARA, Manabu, 1992. Development of Sue ware production. *New Edition of Ancient Japan*, Vol. 5, 149–168. Kadokawa Shoten, [藤原学 「須恵器生産の展開」『新版 古代の日本』].

FUKAZAWA, Yoshiki, 2011. Genealogy of the tunnel kiln. *Publications of the Nara National Cultural Properties Research Institute*, 85, 157–192. [深澤芳樹「窖窯の系譜」『奈良文化財研究所学報』].

HISHIDA, Tetsurō, 2007. *Archeology of the ancient state formation in Japan*. Kyoto University Press. [菱田哲郎『古代日本 国家形成の考古学』].

HASHIGUCHI, Tatsuya, 1982. A few examinations on Dojil-ware. *Kodera mound burials*, 24–31. Amagi City Board of Education. [橋口達也「陶質土器についての若干の考察」『古寺墳墓群』].

Institute of Cultural Relics and Archaeology of Guangzhou, 1998. Preliminary Report on the Excavation of a Southern Dynasties Tomb at Meihuacun, Dongshan, Kaigu, 1998–7, 28–44. [広東省文物考古研究所・博羅県博物館「広東博羅県園州梅花墩窯址的発掘」『考古』].

JEONG, Il, 2008. Kilns for pottery in Baekje period viewing from Gwanju Hengam-dong site: focusing on 5th to 6th century. *Proceedings of 58th extension lectures for Baekje studies*. Baekje Research Institute in Chungnam National University. [鄭一「光州행암동遺跡을 통해본 百済時代 土器窯' 5〜6 世紀를 中心으로」『第 58 回百済研究所公開講座』].

JEONG, Inseong 2013. Prediction for the early culture of Wiman Choson, Study for Ancient Iron culture in East Asia, *International Symposium on Ancient Ironware Culture in East Asia*, 79–114. Korean Research Institute of Cultural Heritage. [鄭仁盛「衛満朝鮮의 初期文化에 대한 予察」『東아시아 古代鉄器文化研究国際심포지엄』].

JEONG Seongmok, (Translated by Koike Fumiaki.) 2012. A note on analysis on the kiln for the burial big jars: in the view of the construction of Oryan-dong kiln site in Naju city. *Journal of the Society of Kyushu Prehistoric and Ancient Cultural studies*, 67, 233–243. [鄭聖睦（訳:小池史哲）「大型甕棺窯の構造分析試論」『古文化談叢』].

KANEGAE Kenji, FUKUDA Masaaki, 2006. Basic Study on Coloring Techniques of Korean style pottery and Lelang style pottery. *Archaeology and natural science*, 52, 51–65. [鐘ヶ江賢二、福田匡朗「韓半島系土器・楽浪系土器の発色技術についての基礎的研究―胎土分析と色調 の計量的分析を通じて―」『考古学と自然科学』].

KANEGAE, Kenji, NAGATOMO Tomoko, ISHIKAWA Takehiko, FUKAZAWA Ttaro, OHIKATA Iichiro and MUNEGAMI Toshiji, 2017. Clay Analysis of pottery excavated from Piziwo in Liaoning Province. *Comparative Archaeology between Japan and Korea on the Development of Pottery Production System and Political Growth before and after the Introduction of Kilns*, 5–10. Result Report of JSPS Grant-in-Aid for Scientific Research (C) 2013–2015. [鐘ヶ江賢二、長友朋子、石川岳彦、深澤太郎、大日方一郎、棟上俊二 「遼寧省普蘭店市貔子窩出土土器の胎土分析」『窯導入前後の土器生産体制の進展と政体の成長に関する日韓の比較考古学』2013～2015 年 度科学研究費補助金基盤研究(C)研究成果報告書].

KAMEDA, Shuichi, 1989. A brief review on ceramic supporter of paddling: with introducing of Deai Kiln. *Archaeology for production and distribution*. Professor Koichi Yokoyama retirement commemorative organization. [亀田修一「陶製無文当て具小考―播磨出合窯跡出土例の紹介をかねて―」『横山浩一先生退官記念論文 集 I 生産と流通の考古学』].

KAMEDA, Shūichi, 2008. Examination of Harima Deai Kiln Site. *Essays on Archaeological research of Okayama University of Science*. Study group for *Archaeological research of Okayama University of Science*, Okayama. [亀田修一「播磨出合窯跡の検討」『岡山理科大学埋蔵文化財研究論集』].

KANG, Kyeongsug, 2005. *Study for the ceramic kiln in Korea*. Singongart, Seoul. [姜敬淑『韓国陶磁器窯跡研究』] .

KIM, Gwangok, 2004. *Study of the pottery kiln in Yeungnam region*. M.A. Thesis at Department of Cultural Anthropology Graduate School in Yeungnam University. [金光玉『嶺南地方 土器가마 研究: 가마構造를 中心으로』].

KIM, Jaecheol, 2007. An essay on the pottery kilns of Proto Three Kingdoms period in Yeongnam region. *Munhwajae: Korean journal of cultural heritage studies*. 40: 35–72. [金才喆「嶺南地方 原三國時代의 土器窯 構造에 대한 예찰」『文化財』]

LEE, Baekgyu, LEE Jaehwan, and KIM Yunhee. 2000, *The Site of Hwangseong-dong, Gyeongju* III. Kyungpook National University Museum, Daegu. [李白圭, 李在煥, 金允喜『慶州 隍城洞 遺蹟』]

LEE, Jiyeong 2008. Changes in the earthenware kilns of the Honam region during the 3rd to 6th centuries, *Honam Archaeological Society*, 30: 65–100. [李志映「湖南地方 3～6 世紀土器窯の変化様相」『湖南考古学報』]

LEE, Sungjoo, 1991. The origin, chronology, and production system of Proto-Three Kingdoms Period ceramic assemblages. *Collected Papers of Korean Ancient History*. 2: 235–297. [李盛周「原三國時代土器의 類型, 系譜, 編年, 生産體制」『韓國古代史論叢』]

LEE, Seongju, 2005. *The Origin and Growth of the Gyae Society in Silla and Gaya.* Yuzankaku. [李盛周 2005『新羅・伽耶社会の起源と成長』].

LIU, Zhenqun, 1982 Relationship between the progress of kilns and the development of early ceramics in China, *Studies on early ceramics in China*, 162–172, Cultural Relics Publishing House. [劉振群「窯爐的改進和我国古陶瓷発展的関係」『中国古陶瓷論文集』 文物出版社]

NAKAKUBO, Tatsuo. 2017. *Forming Process of Ancient State in Japan and Foreign Relations*, Osaka University Press, Osaka. [中久保辰夫『日本古代国家の形成過程と対外交流』]

NAKAMURA, Daisuke, 2015. Technological Transfer of the Iron and Glass Beads to the South of Lelang Commandery, *Journal of Archaeologico-Folkloric Studies*, 95: 33–48. [中村大介「楽浪郡以南における鉄とガラスの流通と技術移転」『物質文化』]

NAKAMURA, Daisuke, 2017. Long-distance trading pottery in the East China Sea and the Yellow Sea, *Comparative Archaeology between Japan and Korea on the Development of Pottery Production System and Political Growth before and after the Introduction of Kilns*, 25–36, Result Report of JSPS Grant-in-Aid for Scientific Research (C) 2013–2015. [「環東シナ海及び黄海における長距離交易土器」『窯導入前後の土器生産体制の進展と政体の成長に関する日韓の比較考古学 』2013～2015 年度科学研究費補助金基盤研究(C)研究成果報告書]

NAKATSUJI, Keita. 2013. Introduction of early Sue ware production around the Seto Inland Sea, *Review of the tumuli near seas III*, 67–76, Study Group of tumuli near seas, Wakayama. [仲辻慧太「瀬戸内海周辺における初期須恵器生産の導入」『海の考古学を考える』]

NAGATOMO, Tomoko, 2008. The production and distribution in the Proto-Three Kingdoms Period,

Journal of Hoseo Archaeological Society 19: 30–57. [長友朋子「原三國時代의 生産과 流通」『湖西考古學』]

NAGATOMO, Tomoko, 2010. Technological Innovation and Production System of pottery in Korean Peninsula, *Machikaneyama Ronso: history*, 44: 31–59. [「韓半島における土器の技術革新と生産体制」『待兼山論叢』]

NAGATOMO, Tomoko, 2019. The origin and diffusion of kiln in East Asia. *The Journal of Cultural Sciences*. 660: 1–17. [長友朋子「東アジアにおける窯の系譜」『立命館文學』]

OKADO, Tetsunori ed., 1995. *Report on the excavation of Suemura and Obadera site,* IV. Center for Archaeological Operations society of Osaka prefecture. [岡戸哲紀『陶邑・大庭寺遺跡』].

OKADO, Tetsunori ed., 1996. *Report on the excavation of Suemura and Obadera site,*V. Center for Archaeological Operations society of Osaka prefecture. [岡戸哲紀『陶邑・大庭寺遺跡』].

PARK, Soohyeon. 2001. An Argument of Pottery Kiln in Honam Region. *Issue of Research,* vol.1. Honam Cultural Propaty Research Center, 41–74. [朴琇鉉「湖南地方 土器窯에 관한 一試論」『研究論文集』].

PARK, Soonbal, 1989. On the Proto-Three Kingdoms Period pottery in the Han river valley. *Journal of The Korean Archaeological Society*. 23: 21–58. [朴淳發「漢江流域 原三國時代 土器의 樣相과 變遷」『韓國考古學報』]

PARK, Sunbal (Translated by KINOSHITA Wataru, YAMAMOTO Takahumi), 2003. *Study on the process of state formation in Baekje*. Rokuichi Shobo, Tokyo. [朴淳發『百済国家形成過程の研究』].

PARK, Sunbal 2004. A Study of the influence of Lorang pottery on the formative Baekje pottery, *Journal of Baekje Research Institute.* 40: 59–72. [朴淳發「百済土器 形成期에 끈 楽浪土器의 影響」『百済研究』]

SAKAI, Kiyoharu. 1994 On the Start of Production of Sue ware Ware in Japan, *Bulletin of the National Museum of Japanese History*, 57: 265–311. [酒井清司「わが国における須恵器生産の開始について」『国立歴史民俗博物館研究報告』]

SAKAI, Kiyoharu, 2004 The Beginning of the Sue Ware Production 'Research Report of National Museum of Japanese History, *Bulletin of the National Museum of Japanese History*, 110: 339–365. [斎藤孝正「須恵器生産のはじまり」『国立歴史民俗博物館研究報告』]

SAITO, Takamasa, 1983. Forming aspect of Sanage Kiln, *The journal of the Faculty of Letters Nagoya University*, 84: 169–203. [「猿投用成立期の様相」『名古屋大学文学部論集』]

SHIN, Gyeongcheol, 1980. Reconsideration of before-Christ upper limit theory for Ungcheon culture, *Busan historical review*, 4: 211–265. [申敬澈「熊川文化期紀元前上限説　再考」『釜山史学』]

SHIN, Gyeongcheol, 1986. Regarding appearance of Silla pottery, *Problems in Ancient culture between Korea and Japan*. The Japan–Korea cultural foundation, Seoul. [「新羅の土器発生に対して」『韓日古代文化の諸問題』]

Society for Korean Archaeology (translation: Shoda Shinya and Yamamoto Takafumi) 2013. *The Korean archeology lecture*, Douseisha, Tokyo. [韓国考古学会編(武末純一監訳)『概説韓国考古学』]

TAKAKU, Kenji, 2018 Cultural relics of Lelang commandery in Japan and Korea: Focusing on the upper limit of tumuli in Leland area of Pyongyang City, *Proceedings of 22nd exchange meeting of Ancient History and Archaeolog,* 29–40. [高久健二「日韓の楽浪系文物―平壌市楽浪区域一帯の古墳の上限年代を中心に―」『第 29 回東アジア古 代史・考古学研究会交流会研究発表会資料集』].

TAKESUE, Jyunichi, 1985. Wajil-ware and early Dojil-ware in Gyeonsang-do, Korea. *Journal of the Society of Kyushu Prehistoric and Ancient Cultural studies*, 15, 125–150. [武末純一「慶尚道の「瓦質土器」と「古式陶質土器」－三韓土器の提唱－」『古文化談叢』].

TAKESUE, Jyunichi, 1993. Pottery of Korean Peninsula and Japanese Archipelago. *Gaya and ancient East Asia*: 239–265, Shin-Jinbutsu Oraisha, Tokyo. [武末純一「朝鮮半島半島と日本の土器」『伽耶と古代東アジア』].

TAKESUE, Jyunichi, 2002. Production System of Iron tools in Korean Three Kingdoms. *Archaeological Essay for Korean Peninsula*, 281–328. Suzusawa Shoten, Fukuoka. [武末純一「三韓の鉄器生産体制―隍城洞遺跡を中心に―」『韓半島考古学論叢』].

TANAKA, Kiyomi, 2002. Process of stylized Sue ware, *A festschrift for Shozo Tanabe on his 70th birthday*, 207–226. publication association for A festschrift for Shozo Tanabe on his 70th birthday. [田中清美「須恵器定型化への過程」『田辺昭三先生古稀記念論文集』].

TANABE, Shozo. 1971. The Birth of Sue ware, *Japanese Arts and crafts*, No. 390,2–31. Nihon Bijutsu Kogeisha, Tokyo. [田辺昭三 「須恵器の誕生」『日本美術工芸』].

TANABE, Shōzō, 1981. *Corpus of Sue ware*. Kadokawa Shoten, Tokyo. [田辺昭三『須恵器大成』].

TERAI, Makoto, 2016. Korean Peninsula factor on the steamer of Sue ware. *Bulletin Osaka City Cultural Properties Association*, No. 14, 37–46. [寺井誠 「須恵器似に見られる韓半島的要素」『大阪歴史博物館研究紀要』].

TERAI, Makoto, 2017. Baekje and Mahan type pottery in the Kinki region. *Baekje in Japan: Kinki region*. South Chungcheong Province, Konju. [寺井誠「近畿地域の百済・馬韓系土器」『日本側の百済―近畿地域―』].

UENO, Kōzō, 2002. Reevaluation of TK 73 type: focusing on the rise and fall of one-legged cup. *A festschrift for Shozo Tanabe on his 70th birthday.* Rokuichi shobo, Kyoto. 227–240. [植野浩三「TK73 型式の再評価ー高杯の消長を中心にしてー」『田辺昭三先生古稀記念論文集』].

UENO, Kōzō, 2010. Early Sue-ware Kilns: A comparative study between Japanese and Korean kilns, *22nd East Asian of Ancient History and Archeology*, 221–235. [植野浩三 「初期須恵器窯の様相ー日韓土器窯の比較検討ー」『第 22 回東アジア古代史・考古学研究会交流会』].

UENO, Kōzō, 2015. A compilation of pottery kilns in South Korea 3: Kyeongsangdo. *Bulletin of the study of cultural properties.* 33: 27–48. [植野浩三「韓国の土器窯集成 (3): 慶尚道編」『文化財学報』]

UENO, Kōzō, 2017. A comparative study of the pottery kiln between Mahan, Baekje and Sue ware. *Bulletin of the study of cultural properties*. 35: 29–48. [植野浩三「馬韓・百済の土器窯と日本須恵器窯の比較研究」『文化財学報』]

YAMADA, Kunikazu, 1998. *Study on Sue ware production*, Gakuseisha, Tokyo. [山田邦和『須恵器生産の研究』].

YANG, Hong, 1984. Wu, Eastern Jin and Southern Dynasty cultures and their influence toward the east, *Kaogu*, 1984–6, 564–573. [楊泓「呉・東晋・南朝的文化及其対海東的影響」『考古』].

YAMAMOTO, Takahumi, 2018. Diversity of Stoneware Production and Distribution during Three Kingdoms Period on the Korean Peninsula. *proceedings of 8th Worldwide Conference of the SEAA*, Nanjing.

YEON Ong, JUNG Sungmok, O Dongseon, GANG Gwihyeong, SIM Jinsu 2011. *Report on the excavation of the pottey kiln site of Naju Oryang-dong*, I. Naju National Research Institute of Cultural Heritage. [연옹・정성목・오동선・강귀형・심진수 『羅州 五良洞窯址I』].

ZHUSHCHIKHOVSKAYA, Irina S. and NIKITIN, Yuri G. 2017. A ceramic kiln in ancient times in southeastern Russia. *Comparative Archaeology between Japan and Korea on the Development of Pottery Production System and Political Growth before and after the Introduction of Kilns*, 67–79. Result Report of JSPS Grant-in-Aid for Scientific Research (C) 2013–2015, 67–87.

XIONG Haitang, 2014. *The Development and Interaction History of Ceramic Industry in East Asia*. Hakyeonmunhwasa, Seoul. [熊海堂 2014『東아시아 窯業技術 發展과 交流史 研究』]

3

The Basic Concept and Appearance of Tunnel Kilns: Ethnoarchaeology and Sue-Ware Kilns from the Point of View of Experimental Archaeology

Masaaki Kidachi

Translation from Japanese into English: Robert Sträter

Abstract: The author describes the principle of the kiln drawing flames from the basic design of the kiln, the inclination angle of the floor, the relationship between the volume of the firing section and the opening area of the firing and smoke outlet, and the temperature of the room. Furthermore, the points to be noted when excavating a kiln are described separately for the firing port, the combustion and firing sections, and the ceiling of the firing section. In addition, from the results of experiments on Sue-ware *anagama* kilns, the color tone and temperature difference, stress on the kiln itself, refractoriness of the soil and fuel consumption are explained.

Keywords: Structure of kiln, tunnel kilns, flame ignition, inclination angle, temperature difference, color tone, stress of Sue-ware kilns

3.1. Firing principle of tunnel kilns: about "pulling the flame"

Climbing kilns are made and built on slopes. However, depending on the construction of the kiln type, the choosing of a site changes significantly. Construction and site conditions of a kiln are in a symbiotic relationship.

*3.1.1. The ignition and extinguishing of embers (***oki***)*

When modern potters fire with tunnel kilns or multi-chambered climbing kilns (*Renbō-shiki Noborigama*, Fig. 3.1), they pay attention to the intensity of the flame. They may notice a stagnation of temperature during the firing, perhaps because the fire does not burn well even though plenty of fuel has been added. Potters describe this state as "pulling the flame." To ensure the correct temperature, different measures must be applied. For instance, by mixing and piling up the accumulated charcoal in the firebox and supplying oxygen to the smoldering charcoal, the firing is accelerated. Other measures include shifting the thrown-in burning material, exchanging large pieces of firewood with fast-burning scantlings, or closing and opening the flue.

If the fuel burns well, the firewood ignites, and after heat emission, it turns to embers. The embers cover the entire floor of the firebox and keep the interior of the kiln warm. Nevertheless, if too many embers accumulate, adding the next batch of firewood makes the space smaller, which causes a hard burning of the firewood so that the embers are scratched out from the firebox. Regarding the color of the embers, some potters differentiate between "bad embers" (extinguished embers) and "good embers." "Bad embers" are dark and never burn out well. "Good embers" are bright, burn down smoothly, become ash, and the speed at which the next firewood is replaced by new embers is fast. We can say that the renewal of firewood and embers is the decisive factor for the temperature rise in the kiln. On the other hand, if the embers, which kept the kiln warm, are scratched out, the temperature of the interior of the kiln will fall suddenly. This does not mean that it returns to zero, because the entire kiln has already accumulated heat, but it wastes time and fuel.

According to modern potters, the ignition of embers can be good or bad. The reason is not only the kiln's construction; some other causes like changes in the environment or the kiln firing may be assumed. Not all causes can be made clear, but first, the basic concept of kiln firing should be explained.

3.1.2. The principle of the flame's ignition

If the supply of oxygen and carbon dioxide is optimal, even when the space is closed, the burning will be accelerated. A tunnel kiln was dug like a tunnel in a slope, and air flows one way from the stokehole to the flue hole. This flow becomes proportionally faster if there is a significant difference in height between the stokehole and the flue hole. If the stokehole's outlet area and the flue hole are large, it becomes proportionally faster.

Inclination angle of the floor and basic design of kilns. Takuma Yogo points out the importance of the ratio of the