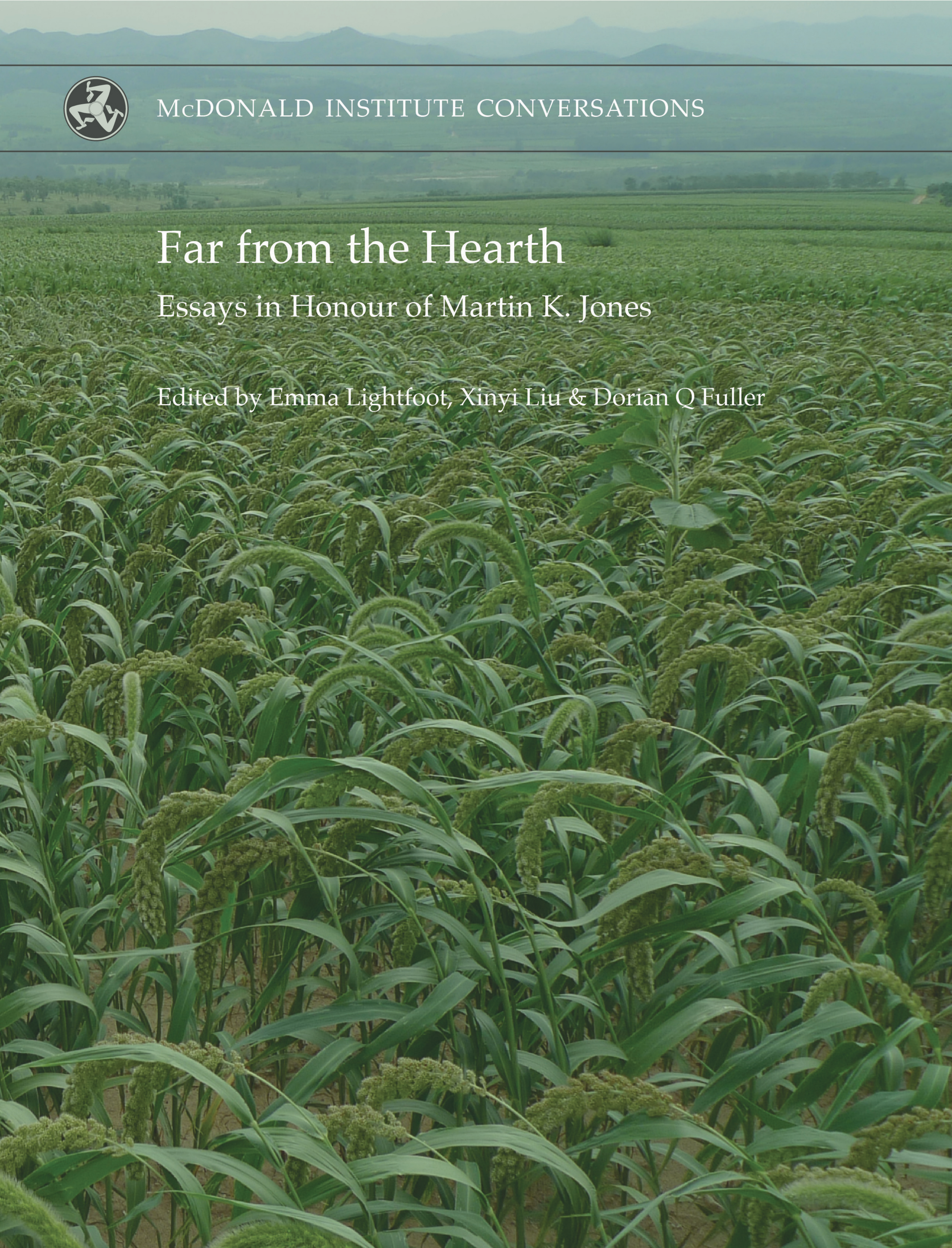
McDONALD INSTITUTE CONVERSATIONS

Far from the Hearth

Essays in Honour of Martin K. Jones

Edited by Emma Lightfoot, Xinyi Liu & Dorian Q Fuller



Far from the Hearth

(Above) Martin Jones at West Stow, 1972 (with thanks to Ian Alister, Lucy Walker, Leonie Walker, and West Stow Environmental Archaeology Group); (Below) Martin Jones in a millet field, Inner Mongolia, 2010. (Photograph: X. Liu.)

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Cover image: *Foxtail millet field near Xinglonggou, Chifeng, China, photographed by Xinyi Liu, September 2014.*

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Figures

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Acknowledgements

The initial idea of editing this volume grew out of a conversation between Xinyi Liu and Graeme Barker at St John's College, Cambridge in June 2016. The editors subsequently discussed the provisional layout of the volume. By April of the following year, our list of agreed contributors was complete. Abstracts followed, and the chapters themselves soon after. First of all, the editors would like to pay tribute to our 36 authors, whose excellent work and timely contributions made it all possible.

For the last two-and-a-half years, the volume has been known as 'Fantastic Beasts' in order to keep it a secret from Martin. As we enter the final stage, we wish to extend our thanks to all who have ensured Martin remains blissfully unaware, including Lucy Walker, and we offer her our sincere thanks. We are extremely grateful to Harriet Hunt, Diane Lister, Cynthia Larbey and Tamsin O'Connell, who are kindly organizing the gatherings to mark Martin's retirement and the publication of this volume.

With respect to the volume's production, we would like to thank the McDonald Institute for Archaeology Research for financial support. The McDonald Monograph Series Editor James Barrett oversaw and encouraged all aspects of this project, and we offer him sincere thanks. We would also like to acknowledge the support of Cyprian Broodbank, not least for allowing us to host the workshop at the institute, but also for his encouragement throughout all phases of the volume's implementation. Particular thanks must go to several key individuals: Anne Chippindale, Ben Plumridge, Emma Jarman, Simon Stoddart and Samantha Leggett. Finally, we are also grateful to the anonymous reviewers who recommended changes that have greatly enhanced the final version of this volume.

Xinyi Liu, Emma Lightfoot and Dorian Fuller
August 2018

Foreword

The 28-year term of Martin Jones as the first George Pitt-Rivers Professor of Archaeological Science witnessed, and in part created, a transformation in the fields of environmental and biomolecular archaeology. In this volume, Martin's colleagues and students explore the intellectual rewards of this transformation, in terms of methodological developments in archaeobotany, the efflorescence of biomolecular archaeology, the integration of biological and social perspectives, and the exploration of archaeobotanical themes on a global scale. These advances are worldwide, and Martin's contributions can be traced through citation trails, the scholarly diaspora of the Pitt-Rivers Laboratory and (not least) the foundations laid by the Ancient Biomolecules Initiative of the Natural Environment Research Council (1989–1993), which he chaired and helped create. As outlined in Chapter 6, Martin's subsequent role in the bioarchaeology programme of the Wellcome Trust (1996–2006) further consolidated what is now a central and increasingly rewarding component of archaeological inquiry. Subsequently, he has engaged with the European Research Council, as Principal Investigator of the Food Globalisation in Prehistory project and a Panel Chair for the Advanced Grant programme. As both practitioner and indefatigable campaigner, he has promoted the field in immeasurable ways, at critical junctures in the past and in on-going capacities as a research leader.

The accolades for Martin's achievements are many, most recently Fellowship of the British Academy. Yet it is as a congenial, supportive—and demanding—force within the Pitt-Rivers Laboratory that the foundations of his intellectual influence were laid. Here, each Friday morning, the archaeological science community would draw sticks to decide who would deliver an impromptu research report or explore a topical theme. Martin is among the most laid-back colleagues I have worked with, yet simultaneously the most incisive in his constructive criticism. As a provider of internal peer-review he was fearless without being unkind. The themed Pitt-Rivers Christmas parties were equally impactful—on one occasion Alice Cooper appeared, looking ever so slightly like our professor of archaeological science.

Martin's roles as a research leader extended to several stints as head of the Department of Archaeology, chairing the Faculty of Archaeology and Anthropology and serving as a long-term member of the Managing Committee of the McDonald Institute for Archaeological Research. Having started his professional career as an excavation-unit archaeobotanist in Oxford, he was a long-standing proponent of the highly successful Cambridge Archaeological Unit. In the wider collegiate community, he is a Fellow (and was Vice-Master) of Darwin College and was the staff treasurer of the Student Labour Club. In all roles he fought valiantly and often successfully for the interests of his constituency. His capacity to fight for deeply held priorities while recognizing the value of diverse perspectives was of utmost importance. His nostalgic enthusiasm for the debate with archaeological science that was engendered by the post-processual critique is one signal of an underlying appreciation of plurality. His active support for the recent merger of the Divisions of Archaeology and Biological Anthropology, within our new Department of Archaeology, is another. As a scientist (Martin's first degree, at Cambridge, was in Natural Sciences) he values the peer-reviewed journal article above all scholarly outputs, yet has authored as many highly regarded books as a scholar in the humanities. His *Feast: Why humans share food* has been translated into several languages and won Food Book of the Year from the Guild of Food Writers. He views academia and society as a continuum, campaigning for archaeobotanical contributions to global food security (e.g. by promoting millet as a drought-resistant crop) and working with world players such as Unilever to encourage archaeologically informed decisions regarding food products.

That Martin's achievements and influence merit celebration is clear. That his colleagues and students wish to honour him is equally so. Yet does the McDonald Conversations series publish *Festschriften*? This is a semantic question. As series editor I am delighted to introduce a collection of important papers regarding the past, present and future of archaeobotany, representing its methodological diversity and maturity. That this collection concurrently pays respect to a treasured colleague is a very pleasant serendipity.

Dr James H. Barrett

Chapter 11

Rice and the Formation of Complex Society in East Asia: Reconstruction of Cooking through Pot Soot- and Carbon-deposit Pattern Analysis

Leo Aoi Hosoya, Masashi Kobayashi, Shinji Kubota & Guoping Sun

Introduction: cooking and society

This article examines the possibility of reconstructing ancient cooking methods to interpret structural shifts in society, focusing on the formation of rice farming-based complex societies in East Asia. Recently, diverse methods of reconstructing ancient cooking have developed remarkably (e.g. Heron *et al*. 2016a,b). This article uses cooking pot soot- and carbon-deposits analysis (Kobayashi 2011a): cooking traces left on pots, mainly soot- and carbon-deposits, are systematically analysed to reconstruct the preparation of daily meals.

In the archaeological study of the history of human subsistence, research has focused predominantly on farming and animal husbandry techniques and the introduction, dispersal and development of domesticated plants and animals. This approach was rooted in the concept that societies before and after farming or animal husbandry were in clearly different stages of human history. This idea stems from the work of Childe (1936), wherein the origin of farming and animal husbandry is the most significant issue in history. However, recent archaeobotanical research has demonstrated that even after the introduction of farming, basic subsistence strategies did not greatly change for hundreds to thousands of years. This is the case both in Near Eastern wheat farming (Tanno & Willcox 2006) and in East Asian rice farming (Fuller *et al*. 2009; Nakamura 2010). Archaeobotanical and archaeofaunal evidence from early rice farmers' sites on the Yangtze indicate that these communities continued to practice broad-spectrum subsistence strategies, including hunting, gathering and fishing, rice cultivation being only a small part of the food-procurement system (Fuller *et al*. 2009; Kohmoto 2001; Nakamura 2002). Moreover, this broad-spectrum economy remained stable for hundreds of years. These new insights have led to the growth of research in the reconstruction of food-processing activities, including cooking, to learn how various types of food were managed in daily meals.

Food processing to make plant and animal tissue edible is as vital for human living as food procurement such as gathering and cultivation. Without processing, the nutrition of most natural resources is inaccessible to humans. Furthermore, food processing is a research scope which can be applied both to societies without farming and those with it, with the same standard. Therefore, societies with broad-spectrum subsistence strategies, which cannot be clearly defined to be either before or after farming, can still be effectively studied within this scope. Many processing activities (crop dehusking and cooking) likely took place within settlements. Thus, food-processing activities, work areas and scheduling must have been incorporated into the domestic cycle. It may therefore be possible to reconstruct routine food processing among ancient people by synthesizing what we already know about their processing facilities, tools and work areas, as well as the organic debris found within a site. If we identify distinct food-processing stages within a settlement, we can better interpret the scale and frequency of each group of activities, how they were organized on a daily basis, and chronological shifts and regional diversities in these activities. Within the study of the archaeobotany of macro plant remains, a methodology to reconstruct stages in crop processing and its contexts at an archaeological site was previously established (Hillman 1981; Jones 1985), but it lacked detailed discussion of the stage of cooking. Subsequently, however, remarkable developments in analytical techniques, such as ancient starch analyses (Fullagar 1998), carbon and nitrogen isotope analyses of food residue (Mason & Hather 2002) and analyses of cooking-pot soot and carbon deposits (Kobayashi 1996) enabled more detailed studies of ancient cooking.

The study of cooking, although until recently underestimated partly due to gender bias (Hastorf

1991), is an effective way of studying past culture and society, because cooking is the basis of daily living and thus reflects cultural and social frameworks. Fuller and Rowlands (2011) claimed that although ethnographers had examined culinary systems as bearing the cultural schema of their communities, built up within rich symbolic systems, their viewpoint was not adopted in the study of long-term history. They noted that although archaeological studies had discussed the social significance of culinary culture, they tended to focus on special occasions, such as feasting, rather than on quotidian food consumption; alternatively, they investigated food itself, not prime movers in driving subsistence and increasing food production. As an effective starting point for the consideration of long-term connections between food and cultural tradition, Fuller and Rowlands (2011) studied techniques of food preparation in prehistoric eastern and western Eurasia. They found that the culinary cultures of eastern and western Eurasia were based on boiling and grinding (baking), respectively. Thus, not only 'powerful forces of technological and subsistence conservatism' but also 'the combination of technological traditions engrained within cosmological frameworks' characterize food culture. Their work showcases the potential of archaeological culinary study as social study.

As acknowledged by Fuller and Rowlands (2011), especially in the rice-farming areas of East and Southeast Asia, cooking rice plays a remarkably significant role in daily life. Characteristically, in those areas, rice is distinctly categorized as the staple, and it is clearly distinguished, conceptually, from side dishes. The heavy dependence on one type of crop as the main food, both from a practical and a conceptual viewpoint, means that the use of rice and how to manage its production and consumption may have been the core of social organization. For example, in Japan, rice was both the practical basis of governmental organization and a symbolically important food at latest by the seventh to eighth centuries AD (Hosoya 2012) and has since this time been deeply connected with Japanese identity (Ohnuki-Tierney 1994). Accordingly, shortages of rice, such as after a poor harvest, have caused severe social disturbances, so-called 'rice riots', a number of times throughout Japanese history (Kanazawa *et al*. 2016). The most recent of these occurrences took place as recently as 1993, and it is clear that the problem was not any actual shortage of food, as there were other types of food in abundance, but entirely due to mental uneasiness. Interestingly, Japanese culinary culture had already been largely Westernized at that time; in fact, government statistics show that consumption of rice per person had been decreasing since 1962 (Ministry of Agriculture, Forestry and Fisheries 2017). Nevertheless, a rice riot occurred. This indicates rice's remarkable symbolic power to influence society even today, beyond its practical significance. Exploration of when and how this power of rice began is vital for understanding the social history of East Asian rice-based societies. Moreover, within this scope, we may be able to construct social formation models constructed only on East Asian evidence, rather than applying Western models.

The reconstruction of ancient rice cooking is the most useful initial step for this discussion. The methods of rice cooking are particularly diverse and complicated compared to the preparation of other food plants/animals (Kubota *et al*. 2017). Rice can be cooked by being boiled, steamed, parched and powdered to make bread, dumplings or noodles (Nakao 1972). Furthermore, there are several variations on boiling, such as *yutori* (boil-and-steam), *takiboshi* (letting the water be absorbed up into rice), pasta-like boiling and frying before boiling (Nakao 1972; Okada 1998). The most common way of preparing rice in modern Japan is the *takiboshi* boiling, while *yutori* boil-and-steam is broadly used in Southeast Asia (Kobayashi 2011a). Rice-cooking methods differ not only regionally, but also within and between households, where different methods may be used for different occasions. In modern Japan, rice is boiled for daily meals, but for New Year's Day, rice cakes made by steaming and pounding rice are served specially, and the pounding action is considered part of the New Year's celebration. In Bali, which is also traditionally a rice-centred society, not only cooking methods, but also types of rice are thoroughly regulated and used for various occasions (Hosoya 2008). Analyses of cooking-pot soot and carbon deposits bear directly on issues of complex rice cooking and will open a window on East Asian social history in its unique framework.

For the last couple of decades, this direction of research has been actively pursued in the study of Japanese prehistory to the medieval period, mainly led by Kobayashi, and it has also been applied recently to a Neolithic case for the first time in China. In this article, the results of research in Japan and China are compared to determine the role of rice in the formation of complex society.

Establishment of rice farming-based complex society in China and Japan

The discovery of the Hemudu site (5000–3300 BC), Zhejiang, China, in 1973 sparked the interest of global researchers due to its remarkable preservation of waterlogged organic material, indicating the existence of rice farming-based civilization in south China (Nakamura 2002). Later, the lower Yangtze River region including the Hemudu site was claimed to be one of the origins of rice cultivation (Yen 1982). The Yangtze River and the southern region of China have been rice based since then.

At present, the beginning of rice farming is considered to lie in the Kuahuqiao culture (6000 BC). Subsequently, the first rice-farming culture was established in the Ningshao Plain and Taihu Lake Plain. Systematic interdisciplinary research has recently been conducted by international research teams at the Tianluoshan (TLS) site (5000–3500 BC) of the Hemudu culture, on the Ningshao Plain, and it has been discovered that rice cultivation was only a part of subsistence, judging from the variety and quantity of plant remains (Fuller *et al*. 2009). The introduction of agriculture did not drastically shift the subsistence system, and hunting, fishing and gathering wild plants continued to form a broad-spectrum economy (Nakamura 2002). The intensification of paddy rice farming, with the introduction of new techniques such as irrigation (Fuller & Qin 2009; Nakamura 2002), eventually occurred between the Songze culture (3800–3200 BC) and the Liangzhu culture (3400–2200 BC) periods, approximately 2000–3000 years after the beginning of rice farming. In the Liangzhu culture, a complex urban civilization with a social hierarchy and work specialization formed (Xu 1998). Thus, it is clear that complex societies based on intensive farming are not merely a natural and inevitable outcome occurring immediately after the introduction of cultivation and domestication. Instead, complex societies emerge from specific shifts in the social organization of the group in question. It remains to be determined what kind of shifts they were and what were the prime movers.

In Japan, rice farming started late, introduced from continental Asia. The first rice-farming culture in Japan is called Yayoi and had its centre in western Japan. The starting date of the Yayoi period has been under discussion for the last couple of decades. The results of dating, depending on the interpretation of AMS, range from the latter half of the tenth century BC to 600 BC, but its ending is generally agreed to fall in the third century AD (Fujio 2017). Subsequently, the Kofun period, with its systematic social hierarchy, began and continued till the seventh century AD. Complex society appears to have formed during the Yayoi period, and approximately 1200 years after the beginning of agricultural society, if the earliest possible starting date of Yayoi is taken. This time span is much shorter than the one for the Yangtze area, which may be because the whole system based on irrigated-paddy rice farming, including the culture, was introduced at once to western Japan (Yamada 2017). It remains unclear what the system was like. In and after the middle Yayoi period, this system was also introduced into the eastern parts of Japan (Yamada 2017).

Although originally Yayoi was defined as a farming culture, in contrast with the previous Jomon hunter-gatherer culture (13,000–1000 BC), for a long time, there has been discussion of the possibility that the Jomon people also cultivated plants (Shitara 2014, 14–29). Based on the results of a series of remarkable developments of analyses of plant imprints on pottery called the replica method, it is believed that dry-field cultivated legumes and millet were a substantial part of Jomon subsistence (Obata 2015). If this is the case, while the Yayoi culture is still distinguished from Jomon by its irrigated rice paddies (it has been discovered that dry-field cultivation was also used regularly in settlements of the Yayoi culture, on a larger scale than previously expected: Kohmoto 2004), the change in subsistence strategies from Jomon to Yayoi was not drastic. Accordingly, it is believed that the system associated with paddy rice farming more significantly characterizes Yayoi culture and played a bigger part in the formation of the complex society that followed than the rice-paddy technique itself.

To examine the prime mover, or the system, functioning behind the formation of complex society based on rice farming in China and Japan, we must study the historical sequence of social meanings of rice. As already discussed, rice in East Asia had remarkable power to influence society as a practical and perceived staple, and it may be that it was a fundamental factor in the formation of complex society. In previous archaeological research, the examination of whether rice was the staple at different times was conducted largely through the reconstruction of the annual yield of rice to determine whether it was enough to sustain the given population (Hosoya 2001). This quantitative approach, however, may be misleading, because being a staple relates to practical and perceived regularity in meals, rather than quantity. In ethnography, the significance of rice in the perception of Japanese people has been used as a clue to the Japanese identity and their culture (Tsuboi 1982); however, this perspective has seldom been applied to the study of extended history. We must develop new methodologies to deal with the social meanings of rice in extended histories. The most effective way of approaching that question may be to reconstruct how people actually ate rice in daily life, as reflected in their processing and cooking.[1] Hosoya (2009; 2014) studied macro plant remains from the Ikegami Sone site in Osaka (middle–late Yayoi) and determined how contemporary community leaders in the latter half of the Yayoi period in western

Figure 11.1. *Burn mark above the waterline after experimental cooking of liquid-rich food.*

Japan extended their centralizing power using rice-processing cycles eventually to establish a classed society. However, this approach, using macro plant remains, is insufficient for reconstructing in detail how rice was eaten as the daily meal. Here, analyses of soot and carbon deposits on cooking pots are introduced as the most effective method of examining that aspect.

Method of analysis of soot and carbon deposits

The study of pottery use beyond typology began to receive research attention in the late 1980s as a direction developing from Processual Archaeology (Nishida 2000). In Japan, research on pottery usage began to be developed in the 1980s, but was rather independent of Processual Archaeology, and it characteristically focuses on the traces of cooking (Nishida 2000). For example, K. Kobayashi (1978) found that clear patterning could be recognized in soot and carbon deposits on Jomon pottery, and a reconstruction of the typical cooking method of the investigated community was made possible. Kawanishi (1982) explored the transformation of cooking from the Yayoi to the Kofun periods, based on transformations in styles, manufacturing techniques and heating traces on cooking pots. In line with those studies, M. Kobayashi has developed analyses of soot and carbon deposits on cooking pots (Kobayashi 1993; 1996; 2011a; 2016).

The basic method of the analyses of soot and carbon deposits on pottery is as follows: 1) the pottery styles are analysed to reconstruct what kind of cooking the pottery makers intended each type of cooking pot for; and 2) the patterns of soot and carbon deposits left on cooking pots are analysed to reconstruct the cooking methods (Kobayashi 2011a). To obtain information on which cooking method leaves which kind of soot or carbon deposits, as a fundamental part of the study, ethnographic research is conducted in communities whose daily practice includes traditional cooking with pottery; such groups are mainly found in Southeast

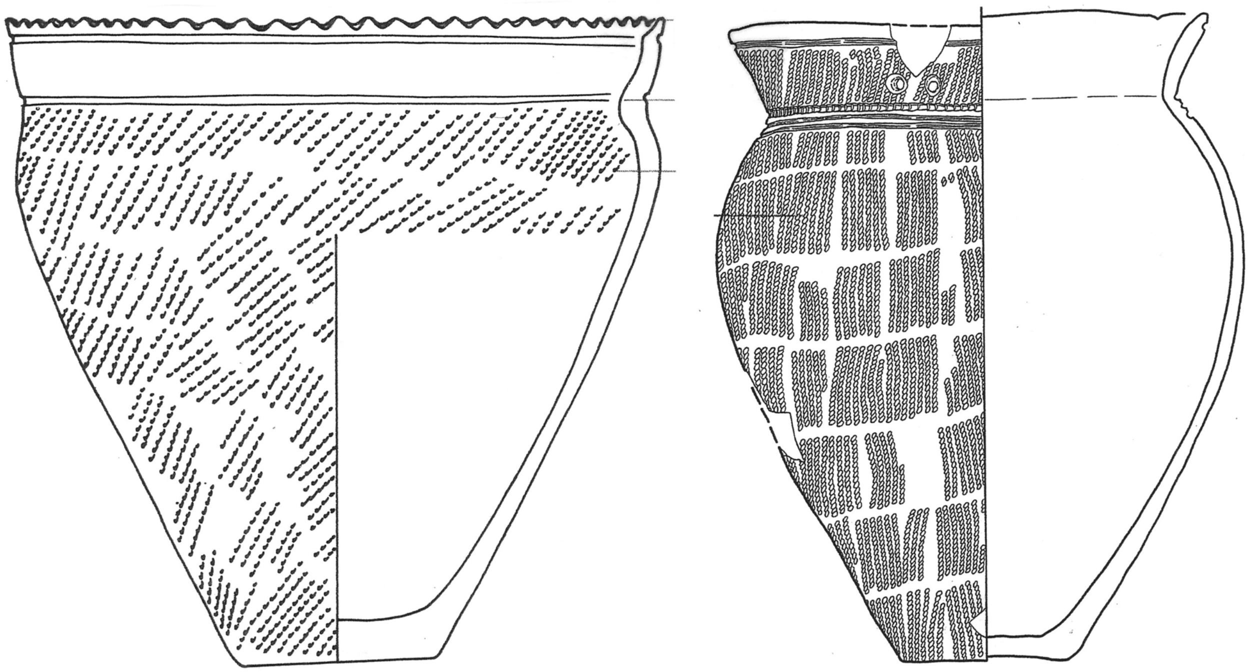

Figure 11.2. *The style of Jomon and Yayoi major cooking pots: (left) Jomon pot (deep bowl, 10 litres) (Kitakami City Education Committee 1988); (right) Yayoi pot (jar, 7 litres) (Aomori Prefecture Education Committee 1985).*

Asia, where there is an emphasis on rice as the staple (Kobayashi 1993). As soot and carbon deposits are the remnants of several different activities, and other complicating factors may be involved, Kobayashi stressed the importance of collecting a broad range of ethnographic examples and introducing experiments in various controlled settings to test hypotheses (Kobayashi 2011a).

Commonly observable soot- and carbon-deposit patterns are as below (Horaguchi *et al*. 2011; Kobayashi 2011a).

Soot: Carbon from the firing material, usually firewood, adheres to the outer wall of the pot. When the soot is touched by high heat, it is oxidized and whitens.

Carbon deposits: The cooked material adheres to or is absorbed into the inner wall of the pot and is carbonized. To analyse patterns of carbon deposits properly, a cross-section of the pottery wall must be observed in addition to the surface. Layered carbon deposits are formed when cooked content eventually loses its liquid and is burnt, for example in rice cooking and simmering a thick stew. Normally, as pots are used, thick carbon deposits are washed out. This means that if they remain for archaeology, they are likely from the final use before it was discarded. In general, liquid-rich cooking leaves carbon deposits above the waterline (Fig. 11.1) and, when the cooking eventually loses liquid, below the waterline.

Stain: Thin, not carbonized, traces of cooked content are observable on the inner walls.

Overflow lines: Traces of cooked material boiled over the rim of a pot and drip onto the outer face. When pots are then later heated after a boiling-over event, the drip becomes carbonized and blackens. Otherwise, the marks are white.

When the patterns in those traces are observed, such as their position, shape, range and thickness, and with reference to ethnographic and experimental examples, various factors can be reconstructed,[2] including the lengths of cooking times, the direction and strength of fires, sequences of cooking, use of stoves or hearths and characteristics of the cooked material. To understand the patterns, sherds are insufficient: pots excavated in mostly complete forms must be analysed. In such analyses, observed soot- or carbon-deposit patterns are recorded on figures drawn from four views (two halves each of the inside and the outside of the pot). Cross-sections of pot walls are also observed as much as possible.

Analyses of soot or carbon deposits can help determine how food was cooked in different contexts, and thus they are particularly well suited for studying rice-centred societies, as ways of cooking rice are various and complex, and the choice of the way of cooking rice often reflects social backgrounds (Section 1). In East Asia, the typology of pottery is remarkably well established (Ohnuki 1997) and archaeologists are well trained to draw detailed figures of artefacts, including pottery (Kobayashi 2011a), which is an advantage in conducting analyses in East Asia. Therefore, there is a high potentiality that this method can open the way to constructing East Asia's own models of social formation.

Case study 1: Japanese Jomon–Yayoi–Kofun pottery

Kobayashi and colleagues have been conducting soot- and carbon-deposit pattern analyses on cooking pots from all over Japan from prehistoric to medieval times. In this article, we review the results of their research from the Jomon, Yayoi and Kofun periods; the timing, from the introduction of rice farming to the formation of complex society, is discussed. The reference throughout this section is Kobayashi (2011a), if not otherwise indicated.

Shifts in cooking pottery styles and soot- and carbon-deposit patterns: Jomon to Yayoi

In the Jomon Period, the main cooking pot was a style of pottery called the deep bowl 深鉢, and in the Yayoi period, a type called the jar 甕 predominated (Kobayashi 1993; Fig. 11.2). However, those traditional archaeological terms are misleading and prejudice the observer against their real usage, so Kobayashi calls both styles of pottery pots 鍋 (Kobayashi 2011b). Following this policy, all cooking pots are called 'pot' in this chapter.

Pots with cooking traces found in 25 Jomon sites all over Japan were analysed to show the characteristics of Jomon cooking pots: 1) their walls are thick; 2) lids are rarely found; and 3) large pots (more than 10 litre capacity) are relatively more prevalent (more than 40 per cent of cooking pots). They exhibit the following patterns of soot and carbon deposits: 1) waterline traces of cooked material are comparatively low down in the body of the pot; 2) carbon deposits can be recognized in the lower part of the inside of body of the pot in more than 75 per cent of all examples, and most of these are above the waterline; 3) soot oxidation is obvious in the lower part of the outside of the pottery, and this position accords with that of the inner carbon deposits; and 4) blackened overflow lines are commonly observed. Furthermore, several cooking pots show post-cooking heating over a low fire, possibly the residual heat of carbonized firewood, in a standing or lying position (Kitano *et al*. 2011). Such characteristics are generally shared by all Jomon cooking pots, regardless of region or phase.

There are few pots which are suitable for soot- and carbon-deposit analyses in the earliest phase of Yayoi (*c*. 1000–800 BC), so the cooking style of this phase is not known; while, from the early phase of Yayoi (*c*. 800–400 BC), Yayoi pots show characteristics that are completely at odds with those shown by Jomon pots (Kanegae 2011). Yayoi pots, according to analyses of more than 30 Yayoi sites, have the following pottery style characteristics: 1) large pots are dramatically fewer in number, and medium-sized (4–7 litre capacity) and small (3–4 litre capacity) pots dominate; 2) pot walls were thinner, their bodies rounder and the neck narrower than those of Jomon; 3) the necks were particularly robust; and 4) lids were commonly found. The soot- and carbon-deposit patterns have the following characteristics: 1) the waterline of the cooked material is comparatively high; 2) carbon deposits can be recognized in the lower part of the inside of pottery, but, unlike Jomon pots, the deposits are mostly observed beneath the waterline and in patches; 3) soot oxidation is not obvious on the lower part of the outside of the pot, but round patches are seen on the upper part; 4) the traces of the boiling over of a cooked meal are not blackened, but white; and 5) no traces of post-cooking heating are found (Kitano *et al*. 2011). It should be noted that such characteristics in soot- and carbon-deposit patterns are particularly obvious in medium-sized pots and less in smaller pots.

In general, the Yayoi characteristics noted above are more obvious in western Japan, which was the centre of Yayoi culture. In northeast Japan, from the middle phase of Yayoi, the Yayoi characteristics of cooking pots are recognized, but showing somewhat longer and higher-temperature heating than western Japanese cases (Kobayashi 2016).

Insofar as Kobayashi's ethnographic and experimental research is accurate (Kobayashi 2011a), the characteristics of Jomon pots indicate that the major meal cooked was a simmered stew-like meal. The thick wall of the pottery is suitable for prolonged simmering and retaining heat after cooking. The heavy soot oxidation on the outside of the pots also indicates prolonged heating, as do the blackened overflow lines, which show that meals that had boiled over were heated further. The low waterline may indicate that Jomon people did not use the full capacity of their pots in cooking meals to avoid boiling over. Further, the lack of carbon deposits beneath the waterline suggests that meals contained a great deal of liquid up until the final stage of cooking, supporting the contention that the meal was stew-like. The lack of lids or lid-rests at the rim indicates that the content was frequently stirred rather than being covered by a lid to steam, and this is well-suited for making stew.

Furthermore, the traces of the heating of pots after cooking on a low fire are not observed in Yayoi cooking pots, only with Jomon pots. This can be a clue to the ingredients. With reference to cooking experiments (Kitano 2009), it is likely that the purpose of post-cooking heating was to burn the food residue clinging to the pot wall to make it easier to wash out and to prevent mould. Sticky food residues are usually produced from mixtures of starchy food and oil (Kitano 2009). The Jomon stew was probably made of starches (wild nuts) and proteins (animal and fish meat). It has been concluded that for common Jomon meals, all food procured was stewed together (Kitano *et al*. 2011). The large proportion of larger pots accords well with the proposal that everything was cooked in one pot.[3] When starch and protein are cooked separately, no sticky food residue is usually produced, so the lack of post-cooking heating traces on Yayoi cooking pots indicates that exclusively starchy food was cooked, as discussed below.

With regard to typical Yayoi cooking pots, particularly the medium-sized ones, their thinner wall indicate that quicker and more efficient heating was preferred to prolonged simmering. Both the round body of the pot and the commonality of lids show that efficient heat circulation was a desideratum. In addition, the high waterline shown by carbon deposits indicates that boiling over was not as much of a concern as in the Jomon period. Accordingly, prolonged simmering did not occur, and cooking times were shorter. The fact that boiled-over contents are not blackened also indicates that they could not be carbonized, due to the short cooking time. The carbon deposits beneath the waterline inside the pot typically consist of a series of round burnt patches, showing that the cooked material had lost liquid by the end of cooking, and organic material touched the pot wall and burnt.

The characteristics of Yayoi cooking pot noted above accord well with rice cooking. In cooking rice, the duration is generally much shorter than that required to simmer a dish, so less boiling-over of contents is expected and the waterline can be high. In addition, heat circulation is more significant to cook rice evenly than to simmer stew, and the round shape of the pots, their narrow mouths and lids and their moderate size are ideal. In some cases, food residues are well preserved in cooking pots, such as at the Joto site, Okayama (late Yayoi), and carbonized rice is often recognized in that (Kobayashi & Yanase 2002). In addition, that those characteristics are more obvious with a particular size of pots, namely, medium-sized ones, suggests that they were specialized rice cookers. Further, the lack of post-cooking traces of heating on Yayoi pots, which may well indicate that starches and proteins were cooked separately, supports the idea of a distinction to be drawn between rice cookers and cooking pots for side-dishes of proteins.

If this is the conclusion, the characteristic round patches of soot oxidation observed on the upper side of the outer wall of mainly medium-sized pots suggest that the method of rice cooking was *yutori*, or boil-and-steam, which is commonly used in modern Southeast Asia. Ethnography from Thailand, Laos, Philippines and Bangladesh (Kobayashi 2011a), where this method is commonly used, tells us that the rice is first boiled with plenty of water and then the pot is removed from the fire and the excess water is taken out (Fig. 11.3). The rice is then steamed on a low fire to be cooked. The final steaming is done through side heating, that is, the covered pot is laid down or inclined and the side is heated (Fig. 11.4). In this way, the upper side of rice, which is not yet cooked through being boiled from the bottom, can be heated as well, and the rice is eventually cooked evenly. Side heating leaves soot oxidation patches on the outer side of a pot similar to those observed on Yayoi pots. In addition, the robust neck of the Yayoi pots accords well with this hypothesis, because in the boil-and-steam method, pots are always removed from the fire by the neck, which needs to be robust enough to sustain the weight of the pot and its contents. In this method, most water is removed after boiling, and the remaining water is entirely absorbed by the rice during steaming, which is likely to leave carbon deposits in patches beneath the waterline, as is observed in the Yayoi pots. Furthermore, it has recently been recognized that in many cases of Yayoi pots, white overflow lines change angle in the middle; straight down first, then going at an angle (Kobayashi 2016). The trace is interpreted to show the pot was tilted to drain water (see Fig. 11.3) just after boiling-over of the meal began, further supporting that the boil-and-steam method was used with Yayoi pots (Kobayashi 2016). Thus, typical cooking methods in Jomon and Yayoi were entirely different, although the shift in subsistence strategy itself may not have been drastic (Section 2). The standard way of cooking rice (the boil-and-steam method) among Yayoi people and its specialized cooking vessel were already established from the earliest part of the Yayoi period. This suggests that rice as a staple began at the same time as the Yayoi culture, so the shift between Jomon and Yayoi was much clearer in perceptions of meals than in proportions of food.

Figure 11.3. *Removing excess water after boiling rice (Central Thailand). (Photograph: Masashi Kobayashi.)*

Shifts in cooking pottery styles and soot- and carbon-deposit patterns: Yayoi to Kofun

Ten Kofun sites were analysed for soot- and carbon deposit patterns on cooking pots. Up through the early Kofun period (third to fourth centuries AD), the basic structure of cooking pots was the same as it had been during the Yayoi period: medium-sized (3–4 litres) and small (1–2 litres) pots are the majority, and the carbon deposits beneath the waterline in a series of round patches are particularly observed on the medium-sized pots. This is evidence that the same rice-cooking method continued. From the latter half of the early Kofun to the middle Kofun periods (the late fourth to

Figure 11.4. *Steaming stage of the* yutori *boil-and-steam rice-cooking method reconstructed with Yayoi pots.*

the early fifth centuries AD), cooking pots became larger and longer both in western and eastern Japan: pots with more than 5–6 litre capacities became the majority, but the rice-cooking method remained the same.

However, during the middle Kofun period, cooking stoves were introduced from continental Asia and cooking styles appear to have changed. At fifth-century AD sites in western Japan, cooking pots consisted of long-body pots (approx. 5–10 litre capacity), large, medium-sized and small round-body pots, shallow pots and steaming baskets. A similar composition of cooking pots is also found at contemporary sites in eastern Japan, so although western Japan appears to have been where new items from continental Asia were first received, these spread to eastern Japan quite quickly. A difference can be found in the shape of cooking stoves between western and eastern Japanese: western Japanese ones have only one hole where pots can be placed and eastern ones have two. It appears that in eastern Japan, long-body pots were fixed to the stoves. In both cases, long-body pots were probably used mainly for cooking. Thin stain is observed at the bottom of the inside of these pots in a 4–6 cm band, but no carbon deposits are recognized. It can thus be concluded that these pots were used to boil clear water without any organic material. Considering the emergence of the steaming basket, it appears that in the middle Kofun period, steaming became a common method of cooking both for rice and side-dishes in both western and eastern Japan, replacing the boil-and-steam method.

Throughout the Jomon, Yayoi and Kofun periods, common cooking methods shifted according to cultural background, and rice was a staple from the beginning of the Yayoi period. Let us compare the cooking methods of early Chinese rice-farming society.

Case study 2: Chinese Neolithic pottery

Pottery soot- and carbon-deposit analyses were performed on Hemudu culture (5000–4500 BC) pottery from TLS, in Zhejiang, from 2015 to 2016 (Kubota *et al*. 2017).[4]

Hemudu culture emerged in the Late Neolithic, spreading along the southern coast of the Hangzhou Bay, bordering the eastern part of the Ningshao Plain. The base site is the Hemudu site.

TLS (5000–3500 BC) is located 7 km northeast from the Hemudu site. Eight archaeological layers have been recognized there, and those from Layer 8 to 3[5] are identified as of the Hemudu culture (Zhejiang Archaeological Institute *et al*. 2007). The dating runs approximately: Layers 8–7: 7000–6500 BP; Layers 6–5: 6500–6000 BP; and Layers 4–3: 6000–5500 BP (Nakamura 2010). These layers contain archaeological material that is as rich as that found at the Hemudu site; in particular, Layers 8–5 are waterlogged, and organic remains deposited here are well preserved (Fuller *et al*. 2010). These remains include a broad range of food plants and animals, mainly from the freshwater habitat, including bones of carp, crucian carp, wild geese and the seeds from wild nuts, as well as rice remains, showing subsistence on a broad-spectrum economy (Fuller *et al*. 2010; Nakamura 2002). The majority of plant remains are wild nuts, particularly acorns and water chestnuts, and rice forms 18 per cent of remains in Layer 8–7 and 24 per cent in Layers 6–5 (Fuller *et al*. 2009). Thus, rice does not appear to be the central food source for the Hemudu culture community of the TLS, at least quantitatively. The question arises whether rice was also qualitatively insignificant. To answer it, soot- and carbon-deposit analyses were applied to the pottery found.

Shifts of pottery styles

Four types of cooking-vessel pots 釜 have been recognized at TLS: the slant-rim type (whose mouth's rim sharply slants to the outside), the wide-mouth type, the round-body type and the two-sectioned-body type (the body of this type is cut by two ridges: Fig. 11.5). The slant-rim and wide-mouth pots can be further classified by size: large (with a more than 8 litre capacity), middle (4–8 litres) and small (less than 4 litres). Round-body pots only occur as medium-sized and small, and among two-sectioned-body pots, only medium-sized ones of an approximately 5- litre capacity have been catalogued. Considering its basic shape and late emergence, the two-sectioned-body type is thought to be a transformation of the slant-rim type. From the Hemudu culture layers, approximately 120 pots whose size and shape could be clearly identified were analysed for soot- and carbon-deposit patterns.

The chronological shifts observed in the relative proportions of pot types are given in Figure 11.6. In Layer 8, the oldest, slant-rim pots are more than half of all pots surveyed, and wide-mouth and round-body pots also exist in lower amounts. However, the relative amounts of slant-rim pots decrease later layers, particularly drastically in Layer 5. More round-body and wide-mouth pots are found at this level, and round-body ones are the majority in Layer 5. However, round-body pots are fewer in Layer 3. Two-sectioned-body pots emerge in Layer 6, and their numbers gradually increase in Layer 5-3, which follows Layer 6. Similar shifts in pot types have been observed at the Hemudu site (Fig. 11.6), with the first phase roughly corresponding to TLS Layer 8-6 and second phase to TLS Layer 5.

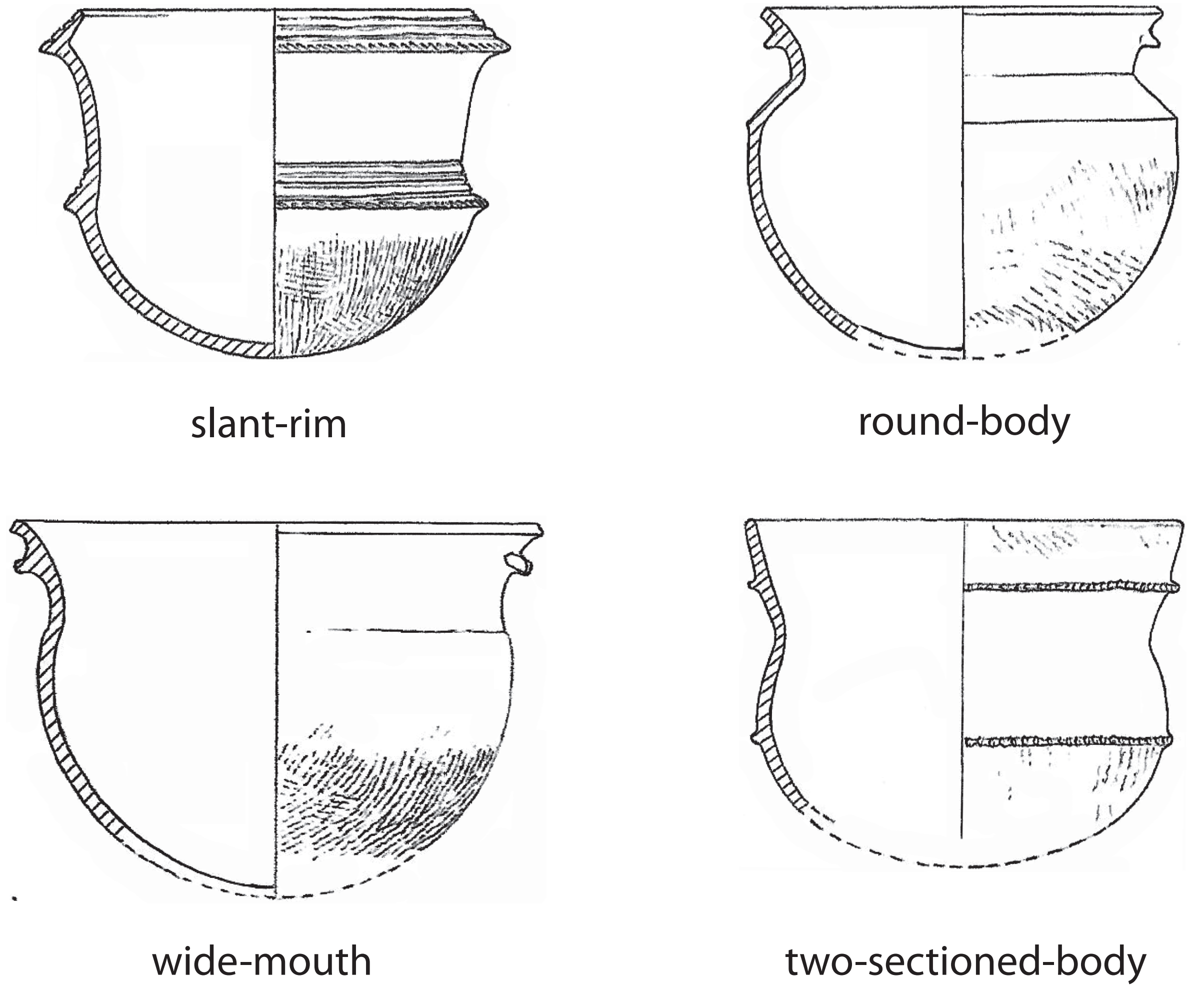

Figure 11.5. *Cooking-pot styles of the Tianluoshan Site (Kubota* et al. *2017).*

Do those shifts reflect changes in cooking styles that took place at the different layers or merely changes in tools for a kind of cooking that remained the same?

Soot- and carbon-deposit patterns

Analyses revealed that each type of pot shows a characteristic soot- and carbon-deposit pattern. It is thus quite possible that those patterns are evidence of cooking styles rather than being taphonomic factors, such as burning after being discarded.

On the inner side of the slant-rim pots, 1–2 mm thick layered carbon deposits are generally found at the bottom and just above these, a burn-trace band is observed. Outside the pot, in the same position as the inner carbon deposits, heavy soot oxidation is observed. Evidence of the use of pot stands in heating is also found. The soot oxidation indicates that the pots were exposed to heavy fire, considering that heavy carbon deposits can be formed by the loss of liquid by the object being cooked and its subsequent carbonization.

Round-body pots generally show the same pattern as slant-rim pots: at the bottom, round soot oxidization is observed on the outside, and at the same position on the inside, layered carbon deposits are found. However, neither the soot oxidization nor the layered carbon deposits are as heavy as those found in the slant-rim pots, so it appears that in the round-body pots, food contents also eventually lost liquid and burnt, but did so on a weaker fire. Soot oxidation patches, unique characteristics of round-body pots, are observed in the middle of the outer body (Fig. 11.7). This means that they were not just heated from the bottom as slant-rim pots were; round-body pots were also heated from the side during a different phase of cooking.

The wide-mouth pots from TLS were generally not clear of soot- and carbon-deposit patterns, but some show only slight carbon deposits at the bottom

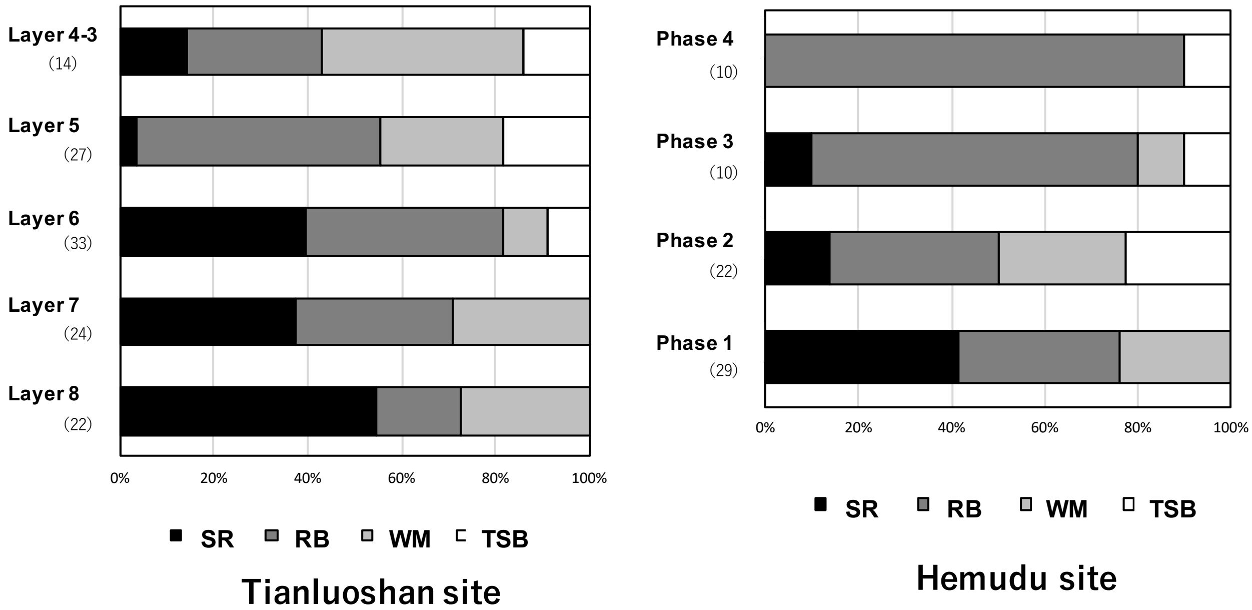

Figure 11.6. *Shift of proportions of cooking-pot styles in Hemudu culture (Kubota* et al. *2017). SR: Slant-rim; RB: Round-body; WM: Wide-mouth; TSB: Two-sectioned-body.*

of the inside and oxidized soot on the outside. It is obvious that their use was different from that of the slant-rim or round-body pots, because the layered carbon deposits and soot oxidation patches characteristic of these types are not found in the wide-mouth type. Judging from their wide-mouthed shape, this type was likely to have been used for boiling, and its contents were kept liquid throughout the cooking operation, so they did not burn.

On two-sectioned-body pots, which appeared only in the latter half of the Hemudu layers, round-shaped soot oxidation is generally observed at the bottom of the outside, as is the case for the slant-rim and round-body pots. However, a clear difference from those two types can be found in that no layered carbon deposits are found at the bottom of the inside. This indicates that with two-sectioned-body pots, things that contained a great deal of liquid, such as soups or stews, were cooked, and the liquid was retained in the dish until cooking was completed. The widened mouths of these pots are also suitable for frequent stirring, helpful in cooking liquid-heavy food.

As above, it can be seen that each type of pot shows a characteristic soot- or carbon-deposit pattern, indicating that different pot types were associated with different modes of cooking and different ingredients. Next, a more detailed reconstruction of the cooking is attempted.

The common factor in soot- and carbon-deposit patterns between slant-rim and round-body pots is the layered deposits of carbon, though the thicknesses

Figure 11.7. *TLS round-body pots characteristic soot and burn mark: (above) soot oxidation patch on the outside; (below) burn mark on the inside (same position as the upper). (Photographs: Masashi Kobayashi.)*

Figure 11.8. *Layered burn deposits formed after experimental porridge cooking. (Photograph: Masashi Kobayashi.)*

of the layers vary. In previous studies, these layered deposits of carbon were without due consideration supposed to be the remains of rice cooking. To determine whether this is indeed the case, the deposits were closely observed. A certain amount of material similar to rice husks was indeed recognized in the deposits in certain amounts. It is believed that rice was dehusked before it was cooked, but when dehusking is done manually, it is difficult to perform perfectly, and some husks likely adhere to the rice grains and are cooked together with them (as Hosoya observed in Bali in 2006–2011). Furthermore, the authors (Kobayashi & Kubota) experimented by cooking rice with the husks, and it was found that, while rice grains were burnt, the husks kept their shape in the layered carbon deposits. Therefore, given that the remains of husks found in the TLS pots were well mixed into the layered carbon deposits, the rice husks were probably parts of cooked material, rather than being a later contamination, and the layered carbon deposits were indeed the remnants of rice cooking. Lipid-residue analyses of those layered carbon deposits also supported this conclusion (Kubota *et al*. 2017). Accordingly, there is a significant possibility that slant-rim and round-body pots were both used to cook rice, at least as part of the ingredients. The difference between the soot- and carbon-deposit patterns between those two types of pots suggests different cooking methods.

It is clear from a close observation of the section of layered carbon deposits of slant-rim pots that the centre is the thickest. Further, the division between the burnt and non-burnt parts on the interior wall is quite clear. Those facts indicate that with this type of pot, rice was cooked with plenty of water, something like porridge. When porridge is cooked, no carbon deposit is generally formed, thanks to the plentiful water, but if the pot is left on the heat before it is served, the amount of water eventually lessens and the porridge on the bottom is burnt, forming a layered carbon deposit thickest at the centre. Furthermore, a band of carbon deposits can be left at the original water line and beneath, although the rest of the pot is clean. Indeed, the results of experimental porridge cooking (a proportion of rice to water of 1:5) in a pottery pot by the authors (Kobayashi & Kubota) showed almost identical soot- and carbon-deposit patterns as that of the slant-rim pots from TLS (Fig. 11.8; Kubota *et al*. 2017). It was suggested by lipid-residue analyses

(Kubota *et al*. 2017) that terrestrial animal meat was cooked within the porridge.

However, with round-body pots, layered carbon deposits have been found, but these are not as thick as those of slant-rim pots; additionally, soot oxidation patches are observed in the middle of the outer body, a unique pattern for this type of pot. That layered carbon deposits are found only at the bottom indicates that rice was cooked in plenty of water at first, but the water was lost, as in the case of the slant-rim pots. However, the thin wall of the round-body pots suggests that they were not left for long on the heat, leading to the conclusion that the loss of water was not the result of vaporization, but was for some other reason. The soot oxidation patches are probably the marks of heating from the side. This pattern is similar to that observed in Japanese Yayoi pots. It may be that the round-body pots were used exclusively as rice cookers for the boil-and-steam method. Round-body pots had already existed at Layer 8, though slant-rim pots were the most commonly found during this time; thus, it is likely that in the early Hemudu phase, rice was cooked as porridge mixed with protein, but also with the boil-and-steam method. Subsequently, in Layers 6–5, rice was commonly cooked separated from other ingredients by the boil-and-steam method.

Interpretation: shifts of cooking styles and the significance of rice

The results of the soot- and carbon-deposit analyses of TLS pots show the following: 1) slant-rim and round-body pots were used for cooking rice; 2) it is likely that slant-rim pots were used to cook rice porridge mixed with terrestrial animal protein, whereas there is a significant possibility that round-body pots were exclusively rice cookers; 3) it is possible that wide-mouth pots were used for boiling food, but the evidence of cooking is not quite clear; and 4) two-sectioned-body pots, which had a late appearance, were used for cooking food like soups or stews.

Combining these results with the facts of the chronological shifts in the relative proportions of pot types (Fig. 11.6), we can create the interpretation below.

During the oldest phase of the Hemudu culture at TLS, namely Layer 8, slant-rim pots are in the majority, indicating that porridge made of rice and protein was the main food. This accords well with the broad-spectrum subsistence strategy reconstructed for this time period from macro plant and faunal remains; food from several sources was eaten together. However, slant-rim pots gradually decreased, and by Layer 5, round-body pots were the majority. It is likely that round-body pots were specialized rice cookers, so it may well be that by the middle of the Hemudu phases at TLS, it became common for rice to be cooked separately from other types of food; at the same time, the method of rice cooking was standardized to boil-and-steam. The dominance of round-body pots indicates that boiled rice was the major food. Wide-mouthed pots were present in the second-greatest numbers. Supposing that this type of pot was used to boil foods other than rice (judging from the lack of layered carbon deposits), it can be concluded that the pots were for cooking side-dishes to accompany rice. In other words, the concept of rice as the staple food might have already been established during the middle of Hemudu culture at TLS. It must be admitted that rice remains are still not a large percentage of food-plant remains even in this phase (Fuller *et al*. 2009), but quantities of macro plant remains can be misleading, as discussed in Section 2. Cooking-pot analyses indicate the established regularity of rice cooking and its distinction from other types of food, regardless of quantity, and thus the change of perception required to give rice special significance over other types of food. A related shift of pottery style also happened at the Hemudu site, as shown above, which may have been the turning point for the entire Hemudu food culture. In Layer 6, two-sectioned-body pots were found to be a likely transformation of the previously existing slant-rim pots, possibly succeeding them in their food-boiling function, but rice may have vanished from among the ingredients used, due to the lack of layered carbon deposits. Therefore, alongside another boiling vessel, namely wide-mouth pots, two-sectioned-body pots may well have been developed to cook side-dishes.

In Layers 4–3, the matrix soil is not waterlogged and the preservation of organic remains is much worse than in Layers 8–5, so detailed soot- and carbon-deposit analyses are impossible. However, it can be recognized that the relative numbers of round-body pots decreased in these layers, whereas wide-mouth pots increased. If rice was already a staple in Layers 6–5, the decrease in round-body pots would be more likely there: the presence of specialized rice cookers indicates a shift in the way rice was cooked, rather than any decrease in rice eating. Indeed, in the Songtze to Liangzhu culture, which chronologically follows, it is highly possible to find a common rice-cooking method of steaming rather than boiling, as indicated by the spread of the set of a steaming basket and vessel (Nakamura 2002). Although this is still speculation at present, it may be that wide-mouth pots were used as a steaming vessel in Layers 4–3, showing that rice steaming was introduced there at the TLS. Matching steaming-basket-like artefacts have not been found in the TLS, but they could have been made of perishable materials, such as leaves. If this is the case, it can be concluded that during the Hemudu culture phases in TLS, rice was first mainly cooked as porridge mixed with other types of food; then, in the middle of the phase, the method of rice cooking was standardized to the boil-and-steam method, as rice became a staple, distinguished from other types of food. Finally, the standard method of rice cooking shifted to steaming in the final phases of Hemudu. Even if the wide-mouth pots of Layers 4–3 were not steaming vessels, it is certain that at the latest, the shift to steaming happened before the end of Hemudu culture.

Discussion

The above shows the results of analyses of soot- and carbon-deposits on cooking pots applied to a Chinese Neolithic case as a first trial. When the results were compared to results of Japanese cases, two main issues are raised, as below.

1) Rice was the staple food

In Japan, particularly in the west, the shift in cooking from the Jomon to Yayoi periods was rather drastic both in methods and vessels, and a standardized rice-cooking method (boil-and-steam) and a specialized vessel were already common at the early phase of Yayoi. Therefore, rice was already clearly established as a staple from the early stage of the establishment of Yayoi society.

On the other hand, the Chinese case at TLS shows rice becoming the staple food in a gradual process. In the early phases of Hemudu culture, the cooking pot soot- and carbon-deposit patterns show that rice was largely cooked mixed with protein foods, indicating that it was introduced as a part of a broad-spectrum subsistence strategy. During the middle phases of the Hemudu culture, rice was more commonly cooked independently of other foods, and the method of cooking (boil-and-steam) and its specialized vessel were established; thus, it probably was a staple at that point. This means that the process went on for hundreds of years.

This conclusion leads to the hypothesis that the clear contrast observable between the Jomon to Yayoi culture in Japan implies that the technique of paddy rice farming and the perception of rice as a staple, along with its proper method of cooking, was introduced from continental Asia to western Japan, rather than that perception being locally developed. It is also likely that the acceptance of the perception of rice as a staple may well have triggered the establishment of the Yayoi society, because it was discovered that total food composition did not drastically change from Jomon to Yayoi (above): the shift in cooking is the most obvious archaeological factor distinguishing the Yayoi culture. If this is found to be true, it is immaterial whether rice itself or the technique of its cultivation was introduced into Japan during the Jomon period, as the shift of perception of rice was the key.

It is intriguing that in both China and Japan, the shift in rice cooking towards becoming a staple happened before the establishment of complex society, rather than after it. This indicates that rice as a staple was a vital factor for the formation of complex society in those areas. Furthermore, it may be that because the social significance of rice had been established, the power centralization necessary to form a complex society could emerge through control of rice production and distribution. Accordingly, if it is supposed that the establishment of the Yayoi culture was marked by the acceptance of perception that rice is a staple, rather than the introduction of the cultivation technique itself, a shorter-term time for the formation of complex society than the Chinese case would be rather natural.

If this is the case, the next question is how and when rice production and consumption came to be controlled by centralized power during the formation of complex society.

2) The change in rice cooking from boiling to steaming

As the cases of China and Japan that we have examined are compared, it is noticeable that in both cases, at a certain point after the boil-and-steam method was established, the method of rice cooking seems to have shifted from boiling to steaming. In the TLS Hemudu culture, this possibly happened in the final phase, certainly before the end. In the Japanese case, this transition happened in the middle Kofun period. If the timing of the shift is examined in both cases, it is possible to conclude that it may have been connected with the control of the production and consumption of rice.

Kobayashi (2011a) once raised the possibility that cultivated rice changed, at the time of the shift in cooking from boiling to steaming, from non-glutinous to glutinous rice, for which steaming is more suitable than boiling. Kobayashi (2011a) noted the greater efficiency of production of glutinous rice than non-glutinous rice to explain the shift in types of rice. However, he and Toyama later contradicted this hypothesis, presenting the evidence that non-glutinous rice had nevertheless been eaten throughout the Kofun period and in the following historical ages (Kobayashi & Toyama 2016). These researchers instead supplied the hypothesis that centralized control of rice circulation was the reason for the shift, as below:

> Although non-glutinous japonica rice was the major rice cultivated in Japan, beginning with the introduction of the cultivation of rice, it has been found in morphology and ancient DNA analyses of carbonized rice remains (Ishikawa *et al*. 2015; Sato 1999) and phytolith analyses (Udatsu 2008) that during the Yayoi to the medieval period there was a shift in the primary rice cultivated and eaten from tropical japonica to temperate japonica. The Kofun period occurs right in the middle of this time of the shift; thus it may be that both types of japonica, and possibly a hybrid, co-existed in whatever proportions.
>
> Still, it is not likely that one household could cultivate different types of rice together, so types of rice may possibly have varied among households or communities. Tropical japonica grains contain more amylose than temperate japonica does, making them less sticky. Using the ethnographic example of the Oy tribe, Laos (Kobayashi & Toyama 2015), it can be seen that when grains of rice that have different amounts of amylose are boiled together, the adjustment of water is quite difficult: if the water is adjusted to the standard of the high-amylose rice, low-amylose rice will melt, but if the water is adjusted for the low-amylose rice, the high-amylose rice will remain uncooked. However, when the rice is steamed, no such challenge occurs with the mixing of high- and low-amylose rice, as the grains of rice do not directly touch water. It is suggested here that in the middle Kofun, people shifted their method of rice cooking from boiling to steaming, because they were eating the rice harvests of other households, not their own alone, which was likely uniform rice type, forcing them to cook rice of mixed origins and mixed types. This indicates that rulers may have controlled rice circulation, collecting harvests from all farmers ruled and redistributing it to them (Kobayashi & Toyama 2016, 71–2, translated by Hosoya)

This hypothesis should be noted, though it remains a speculation until more substantial supporting data, such as greater archaeological information and botanical remains, are collected. In addition, we need to discuss other possibilities why Kofun people started using mixed types of rice, such as for preference of more diverse dishes or for risk-management of crop failure. Still, this hypothesis at least shows the possibility of discussing the issue of the shifting management of rice circulation from a new and clearer viewpoint, namely, in reference to the daily meal, a more substantial level than the previous discussion, which remained merely notional. In combination with reconstruction of the how rice became perceived as a staple, which is hard to discuss while restricting oneself entirely to the analysis of plant remains, the cooking pot soot- and carbon-deposit analyses can open up new vistas for the study of the unique role of rice in the formation of complex society in East Asia, on its own methodological terms. Through the development of these analyses and by synthesising other necessary data, in particular, the chemical analyses of food residue adhering to pots, it will be possible to develop tangible results illuminating the history of rice-based civilization.

Conclusion

It has been examined from multiple viewpoints how dependence on paddy rice influenced the formation of society and worldviews. The classical historian and sinologist Wittfogel (1957) promoted the theory of Oriental despotism, claiming that the bureaucratic structures of the East Asian society are rooted in the organization of the irrigation system for the paddies, calling it the Hydraulic Empire. Recently, Talhelm and colleagues (2014), using the tools and methods of psychology, examined people living in rice cultures, concluding that they are more interdependent and holistic in their thinking than individuals in wheat culture, using respondents from north and south China.

While room remains in these issues for more discussion, it can certainly be agreed that rice, as a staple food, is both physically and symbolically a core factor in the rice-farming societies of East Asia. To understand East Asian society and culture, it is necessary to understand the long-term history of rice in society: when and how it became a staple, over and above other foods, its production and consumption in their political management. However, although technical aspects of rice cultivation, such as the origin and diffusion of cultivation techniques and the breeding sequences, have been exhaustively studied in archaeology, the social aspects of rice are insufficiently examined.

Archaeobotany and archaeozoology, particularly in northwest Europe, have been highlighting since the 1980s–90s that human meals have been a social activity from the earliest stage of human history instead of just a means of obtaining nutrition, and thus they must be studied within the scope of social archaeology. Many researchers have attempted to reconstruct different meanings for food in past societies beyond mere reconstruction of subsistence (Jones 2007). The most effective method for this type of research is to reconstruct food-processing and cooking activities for each archaeological site; in this way, it is possible to reconstruct the social organization and cultural context of those activities (whether they are mundane, ritual or other), and eventually, as a goal, the social meanings of each food. In studying macro plant remains, methods of reconstructing food processing were intensively developed, introducing ethnoarchaeological approaches, and they were applied to several crops in various cases, mainly in Europe (Butler 1992; Hillman 1984; Jones 1985; Reddy 1994) in the 1980s and 1990s, but this research perspective did not find a foothold in East Asia. However, thanks in part to recent progress in analytical techniques, particularly chemical analyses, the goal of determining the meanings of different foods began finally to be sought in Chinese and Japanese cases, with the introduction of those techniques. Currently, intriguing research achievements are being published quite rapidly; for example, a new outlook on Jomon food-processing management and food valuation using analyses of ancient lipids has been published by Heron and colleagues (2016a) and Lucquin and colleagues (2016). It is promising that such new directions of research on archaeological subsistence are leading to a more profound understanding of all of East Asian social history. Still, particularly in Japan, the focus of research is centred on Jomon hunter-gatherer society, and study of the meaning requires extensive further development.

This chapter has attempted to reconstruct the meanings of rice in the formation of complex society in China and Japan, based on analyses of soot and carbon deposits on cooking pots. Although this research is still in a preliminary stage, especially in China, it was clearly shown to be feasible with this method to reconstruct how rice became a staple, following shifts in methods of in rice cooking in connection with the transformation of the social background. It was also suggested that the use of rice in daily meals in a community is surely a good indicator of social transformation. The concept of a staple is itself unique to eastern Eurasia; rice, as a staple, can be efficiently studied to construct social formation models belonging to East Asia.

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Notes

1. Recently it has been generally accepted that ecological characteristics of rice contributed to its becoming the major food. Yet even if so, the process and timing of rice to become a staple are issues of social history; thus historical approaches are needed for the discussion.
2. It must be noted that the soot- and carbon-deposit patterns generally show the last use of the pot. However, if a section of the wall of the pot can be properly analysed, the regular use of the pot can be reconstructed.
3. There is a possibility that especially large pots (larger than 20 litres) were used for blanching wild nuts (Kobayashi 2011a).
4. This study was supported by a JSPS Grant-in-Aid for Scientific Research on Innovative Areas 'Rice Farming and Chinese Civilisation' (FY 2015–2019, No. 1701).
5. In Chinese archaeology, layers are numbered from the latest (upper) to oldest (lower).

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