Quaternary International 441 (2017) 36–48

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

The emergence of pottery in China: Recent dating of two early pottery cave sites in South China

David J. Cohen [a,*], Ofer Bar-Yosef [b], Xiaohong Wu [c], Ilaria Patania [d], Paul Goldberg [d,e]

[a] *Department of Anthropology, National Taiwan University, Roosevelt Rd., Sec. 4, No. 1, Taipei, 106, Taiwan*
[b] *Department of Anthropology, Harvard University, Cambridge, MA, 02138, USA*
[c] *School of Archaeology and Museology, Peking University, Beijing, 100871, China*
[d] *Department of Archaeology, Boston University, Boston, MA, 02215, USA*
[e] *School of Earth and Environmental Sciences, University of Wollongong, NSW, 2522, Australia*

ARTICLE INFO

Article history:
Available online 10 September 2016

Keywords:
South China
Upper Paleolithic
Pottery
Hunter-gatherers
Yuchanyan
Xianrendong

ABSTRACT

The earliest pottery in East Asia, as is found in several cave sites in southern China, emerges in Upper Paleolithic contexts dating from the Last Glacial Maximum, ~20 Ka cal BP. The making of simple pottery vessels in Late Pleistocene East Asia also has been noted in eastern Siberia and Japan but not yet in the Central Plains of China. This paper summarizes the better-reported evidence for early pottery sites across the vast region of China south of the Yangtze River, providing details on two dating projects conducted in the cave sites of Xianrendong (Jiangxi Province) and Yuchanyan (Hunan Province). The excavated contexts in these two caves and a few others clearly indicate that this early pottery was the creation of hunter-gatherers who hunted available game and foraged a variety of plant foods. The nature of the cave occupations is ephemeral, and where the published animal and plant remains allow, we suggest that there were repeated, seasonal occupations. In sum, there is no basis yet to suggest that the making of early pottery in South China marked sedentary or plant-cultivating communities.

1. Introduction

Research over the last several decades is making scholars increasingly aware that pottery manufacture by foragers was a common phenomenon in various regions of the Old World. In East Asia, in particular, pottery production now clearly can be seen to predate sedentism, cultivating cereals, and producing polished stone axes or adzes (Jordan and Zvelebil, 2009; Cohen, 2013). This recognition removes the production of pottery from the traits of the "Neolithic Revolution," a term coined by G. Childe (1936) during the early part of the 20th century. Childe based his definition of the Neolithic on the then available archaeological evidence retrieved from sites across southwestern Asia (the Near East) and Europe, and this resulted in a widespread acceptance of certain cultural "markers" of the Neolithic, including pottery, ground stone tools, and cultivated plants; such traits later became termed the "Neolithic package" (Gibbs and Jordan, 2016).

Chinese archaeologists, arguably through Childe's influence, long accepted the presence of pottery as indicative of a site being "Neolithic" and thus also typically assumed the site likely represented a sedentary occupation of plant cultivators. The discovery of early pottery in Late Pleistocene cave sites in South China originally lead excavators to believe these sites represented occupations by early domesticators of rice, but further work and dating of these sites, as discussed here, however, have led to the realization that pottery in China and greater East Asia was first produced by hunter-gatherers millennia before what in China are called "Early Neolithic" (here meaning sedentary plant-cultivator) sites appear. In China, sites with pottery that date from the Late Glacial Maximum to the early Holocene are now often referred to as "early pottery" sites, and they stand in contrast to the "Early Neolithic" sedentary sites that appear in the early Holocene. Although pottery predates plant cultivation and sedentism, and we must thus remove the invention of pottery from Childe's list of traits marking the Neolithic, Childe's conceptualization of a "Neolithic Revolution"— meaning a fundamental socio-economic transition from foraging to farming and herding that occurs across various geographic regions of the world with concomitant changes in ideologies and belief systems (see Bellwood, 2005)— is still valid in China and elsewhere. In this paper, we discuss the excavations and dating of pottery at the two earliest pottery cave sites in the world,

---

* Corresponding author.
E-mail address: dcohen@ntu.edu.tw (D.J. Cohen).

http://dx.doi.org/10.1016/j.quaint.2016.08.024
1040-6182/

Xianrendong and Yuchanyan caves in South China, and place these caves and other sites in the greater context of Late and Terminal Pleistocene foragers in East Asia.

1.1. Early pottery across eastern Asia

With the onset of the application of radiocarbon dating, archaeologists realized that hunter-gatherers in Japan had been making pottery since the Terminal Pleistocene age. This appearance of pottery vessels within subsistence systems of hunting, fishing, and intensive collection of wild plants in the Late Pleistocene stood in immediate contradiction to Childe's understanding of the role of pottery as he saw it in the Near East and Europe. Recent dating of the earliest pottery in what is now termed the Incipient Jōmon culture in Japan ranges ~16.8–15.3 Ka cal BP (thousands of years, calibrated, before 1950 present) (e.g., Kudo, 2012; Craig, et al., 2013; Yoshida et al., 2013). The earliest pots in Japan and elsewhere in East Asia were handmade ceramic containers fired at moderate temperatures, and, as vessels for storing, preparing, or cooking food, were conceptually different from the earlier use of fired clay for shaping figurines or small objects known from the Central European Upper Paleolithic period, such as at Dolní Věstonice (Jordan and Zvelebil, 2009; Svoboda et al., 2015). In later phases of the Jōmon culture, “low level” plant food production, or what Crawford (2011) calls “resource production,” is recognized as pottery production becomes more and more highly elaborated (Kaner, 2009; Sato et al., 2011; Noshiro et al., 2016), demonstrating that the long tradition of making pots was a continuing activity by foragers that came to take on increasing socio-economic and ideological significance, together with the production of stone tools and objects of organic materials such as bone, antler, wood, and bamboo. Parallel situations, with the elaboration of pottery forms, decoration, functions, and meaning are witnessed as Early Neolithic societies emerge in North and South China ca. 10–9 Ka cal BP (Cohen, 2011).

Japan was not unique in the production of early pottery, as Late Pleistocene sites with pottery were also discovered in the Russian Far East and eastern Siberia, with a series of well-known sites indicating dates for the early pottery of ca. 14,000–15,940 cal BP (Buvit and Terry, 2011; Kuzmin, 2013, 2015; references therein; Tsydenova and Piezonka, 2015; Zhushchikhovskaya, 2009). This additional information from Russia made it fully acceptable that Terminal Pleistocene hunter-gatherers across a wide area of East Asia manufactured pottery, and so it was therefore not surprising that early, simple pottery began also to be found in Late and Terminal Pleistocene cave sites in southern China, as described below. At present, such early pottery, however, remains lacking from northern China, with the earliest pottery there dating to ca. post-12 Ka cal BP: these North China and Central Plains sites with pottery include Yujiagou, Nanzhuangtou, Donghulin, Zhuannian, Lijiagou, and Lingjing (Cohen, 2013; Wang et al., 2015; Li et al., 2016). With earlier pottery known to the north and south of these sites in North China, it is yet unknown why there is no earlier pottery in this region that becomes a major center of early sedentary, plant-cultivating villages in the Early Neolithic of the Central Plains (middle and lower Yellow River basin) in the early Holocene (see Cohen, 2011). It is quite possible that future excavations of more sites that are still buried in the loess deposits in the river valleys of northern China will reveal early pottery in Upper (or “Late”) Paleolithic contexts there.

2. Early pottery in South China

In the following pages we describe the finds from two early pottery-producing cave sites in South China, focusing specifically on issues of radiocarbon dating. The acceptance of the dating of early pottery-containing layers at these sites requires careful understanding of a number of inter-related issues that can impact the quality of the radiocarbon dates, including the selection of excavated areas, the digging techniques of the excavations, and the nature of the deposits in these South China sites. We define South China here as the broad region south of the Huai River and Qinling Mountains. Several cave sites in karst regions found south of the Yangtze River were excavated and published in one form or another, although final reports are still lacking for most. Sites include Xianrendong and Diaotonghuan in Jiangxi Province, Yuchanyan in Hunan Province, Qihedong in Fujian (Fujian Museum, 2013), and Miaoyan (Chen, 1999), Liyuzui (Liuzhou Museum, 1983), Dayan, and Zengpiyan (Institute of Archaeology, Chinese Academy of Social Sciences, 2003) in Guangxi (Lu, 2010, Fig. 1), with the best-dated and earliest sites being Xianrendong and Yuchanyan, discussed here. These sites produced sufficient information to demonstrate that early pottery making occurred within the socio-economic contexts of hunter-gatherers and that they predate by some ten millennia or more sedentism and the emergence of farming during the early Holocene (Cohen, 2013).

2.1. Xianrendong Cave (Jiangxi Province)

Currently the site with the earliest known pottery vessels is Xianrendong Cave, with the earliest layers bearing pottery sherds exposed at the site dating to ~20 Ka cal BP (Wu et al., 2012, and references therein). Xianrendong Cave is located in Wannian County, northern Jiangxi Province, some 100 km south of the Yangtze River. The main cave consists of a large, dark hall with a small entrance, but the prehistoric occupations were in a roofed area at the front that resembles a rock shelter, in back of which is the dark main chamber. The frontal area can be divided by the entrance to the darker hall and an area of consolidated, unexcavated deposits into “Western” and “Eastern” areas. The first excavations were conducted in 1962 and 1964 by the Jiangxi Provincial Cultural Relics Administrative Committee, during which a major portion of the sediments was removed (Fig. 2). In 1993, 1995, a Sino-American expedition directed by Yan Wenming and S. MacNeish excavated a smaller portion of the deposits in order to derive a sequence for and date what was seen then as the emergence of rice cultivation at the site and the presence of early pottery. The field project was completed in 1999 by a team from the School of Archaeology and Museology of Peking University and the Institute of Archaeology and Cultural Relics of Jiangxi Province[1] (MacNeish et al., 1998; MacNeish, 1999; Zhang, 2002a; Sun and Zhan, 2004;

---

[1] The 1962 excavations, carried out by the Jiangxi Provincial Cultural Relics Administrative Committee, opened excavation squares T1, T2, and T3 (see Fig. 2). The 1964 excavations, by the same group, expanded the excavations to squares T4, T5, and T6. The Sino-American excavations in 1993 and 1995 were jointly carried out by the Peking University Department of Archaeology, the Jiangxi Provincial Archaeology and Cultural Relics Research Institute, and the Andover Foundation, with MacNeish being the Principal Investigator for the American team and the Chinese team lead by Prof. Yan Wenming. The 1993 excavations opened squares E0-3N4 (four units in a row of 1 m^2 each), with MacNeish in the field to supervise. The 1995 excavations continued work on these squares and opened three more 1 m^2 units in a row, E11N10-12, with MacNeish in the field to supervise. As there were concerns about the dating and stratigraphy, a Chinese-only team from Peking University and the Jiangxi Provincial Institute returned to excavate in 1999, opening squares E10N10-12 (total 3 m^2) (Peking University School of Archaeology and Jiangxi, 2014, pp. 6–11). The 2009 dating project, by Peking University (Wu Xiaohong directing, Zhang Chi, Qu Tongli), Harvard University and Boston University (Bar-Yosef, Cohen, Goldberg), and the Jiangxi Provincial Institute, opened profiles in what was a baulk between the 1964 T4 and 1993 E0-3N4 excavation areas, and the remaining (west) profile of the 1999 E10N10-12 excavation area (Wu et al., 2012).

Fig. 1. Map of early pottery sites in South China mentioned in the text.

Peng and Zhou, 2006; Peking University School of Archaeology and Jiangxi, 2014).

The Sino-American 1990s expedition also excavated a collapsed cave situated across the valley from Xianrendong originally called Wang Cave but which came to be known as Diaotonghuan Cave. The Diaotonghuan excavations covered a larger surface area and somewhat deeper deposits (MacNeish et al., 1998; MacNeish, 1999; Zhang, 2002a; Sun and Zhan, 2004; Peng and Zhou, 2006; Peking University School of Archaeology and Jiangxi, 2014). An extensive program for radiocarbon dating of both sites was carried out by dating facilities at Peking University (determinations labeled as BA) and the University of California Riverside (UCR). However, a number of critical issues that hindered the establishment of ages for the early pottery at Xianrendong from the old (1962, 1964) and new excavations (1993, 1995, 1999) emerged. These problems stemmed from the following:

1 A stratigraphic assumption was made in digging the East and West areas in Xianrendong cave in the 1990s that layers in these two, separate, small areas are horizontally equivalent (meaning the same depth equaling the same time period) and continuous. However, a distance of several meters of consolidated deposits separated the two areas. The assumption led to the unfortunate circumstance that layers in both trenches were labeled using the same numbering system, such as 2A, 3B1, 3C1A, 3C1B, although, in fact, a layer in the east would be different from one in the west with the same number. In addition to the basic assumption of there being correlations between east and west layers, the labeling system was not immune to labeling mistakes.

2 The trenches excavated in 1993 and 1995 were 1 m wide in the Western Area and in the Eastern Area. The limited sizes of these trenches made it difficult to identify misattributed or correlated stratigraphic units due to the lack of horizontal continuity.

3 It was apparently unclear to S. MacNeish, that the uppermost layers in the areas excavated in 1993 (E0-3N4) and 1995 (E11N10-12), when he was supervising the excavations in the cave, had been removed by the original 1962 and 1964 excavators. These removed layers were likely Holocene and primarily Neolithic, according to pottery and other artifacts found in the 1960s excavations. This removal may have impacted MacNeish's conceptualization of the sequence of the site and not allowed him to realize that there could have been a longer developmental process for the pottery, thus also making him want to accept only the later dates for the earliest part of the sequence.

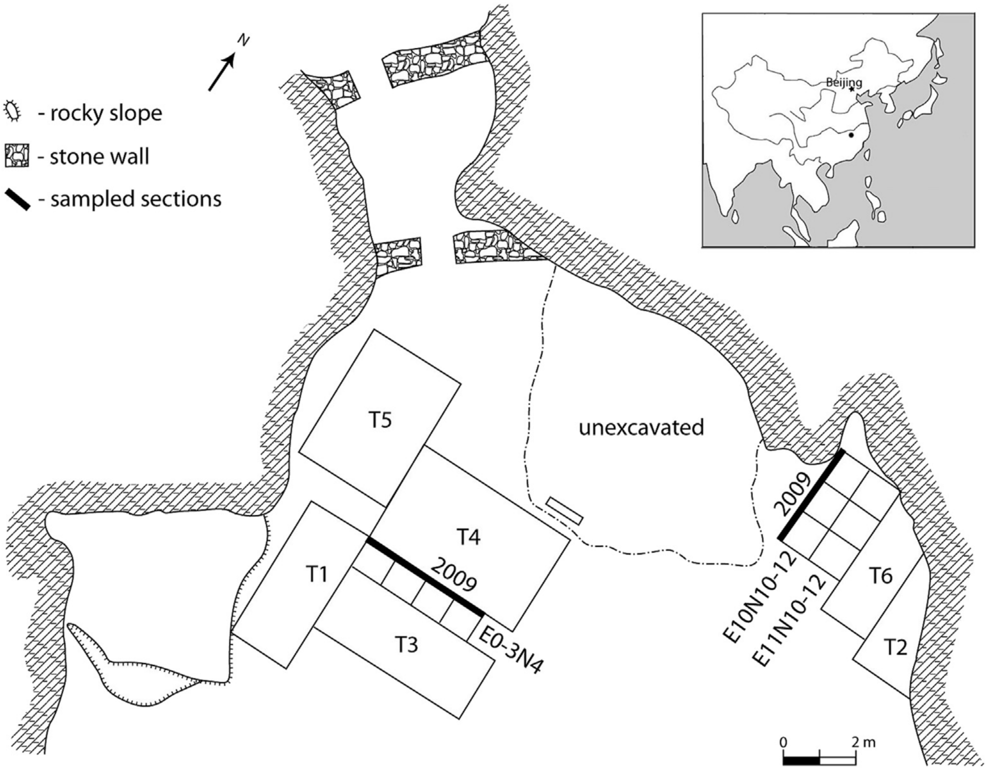

Fig. 2. Plan of the excavations at Xianrendong Cave, Jiangxi, showing the grid from the various expeditions, and (inset) position of Xianrendong Cave in China (from Wu et al., 2012). The cave can be divided into eastern and western areas, with an unexcavated area between them. Squares T1-T6 were excavated in 1962 and 1964. The excavations in 1993–1995 and 1999 opened the smaller units labeled on a cardinal grid (e.g., E0N4, E1N4, etc., in the west section). The locations of the re-opened profiles for the 2009 dating project are indicated with thick black line.

4. During the 1980s–1990s, it was a common – though incorrect – belief in China that the presence of whitish lenses in cave sites such as Xianrendong was the result of accumulated dripping of carbonates from the limestone ceilings, and that these impacted radiocarbon dating, producing “old” dates. This claim is clearly stated by An Zhimin (1991, p. 198) when he writes that “ground water in the region contains a great deal of $CaCO_3$ which comes from dissolution of limestone and is depleted in radiocarbon.” On the other hand, An correctly mentions that “in general it is recognized that dates on shell are likely to be unreliable; much better results can be obtained from animal bone and tree charcoal” (An, 1991, p. 198).
5. The dating of the different layers at Xianrendong conducted by the two laboratories—Peking University and Riverside (California)— which in the 1990s already provided calibrated dates of over 19 Ka cal BP for the lowest pottery-containing layers, was not accepted by S. MacNeish, who led the American side in these joint excavations and who presented most of the dating evidence and descriptions of the excavations before they were recently collated in the published final report (MacNeish et al., 1998). MacNeish rejected 27 out of the 34 available radiocarbon dates. His rejection was based on two faulty premises: first, since Jōmon pottery at the time was dated to not earlier than 12,000 BP, MacNeish believed the Chinese pottery could not be older, as he saw it as similar. Second, following the same belief of several Chinese authorities, expressed by An Zhimin, MacNeish also accepted that charcoal dates in limestone caves are too old due to dripping carbonate-containing water from the ceiling. However, we now know, as mentioned above, first, that Jōmon pottery is over 16,000 years old, and second, based on dating and experimental work conducted in Western Europe and Israel, that the assumption of cave carbonates producing “old” dates is incorrect. This is because the white lenses thought to be carbonates from the ceilings are actually typically composed of calcitic white ash accumulated from burning wood, and the crystal morphology of this ash calcite, which can be distinguished from typical cave carbonates, is readily identifiable (Courty et al., 1989; Schiegl et al., 1994, 1996; Chu et al., 2008). Furthermore, the accumulated experience in cave and rockshelter sites across Eurasia now clearly demonstrates that in the majority of cases, well-preserved bones, as short-lived samples, and charcoal samples from plants, when they are identified, serve as a sound basis for dating past cultures when they generally are younger than 45–40 Ka cal BP.

Additional fieldwork in Xianrendong and Diaotonghuan was conducted in the two caves in 1999, and a few more radiocarbon dates were obtained. The final site report covering the excavations through 1999, in Chinese, was recently published (Peking University and Jiangxi Province, 2014).

Following the 1999 excavations, the same issues and ambiguities in the Xianrendong radiocarbon chronology still remained. These, combined with problems with the suggested interpretations of the radiocarbon chronology of both sites, led a team including the authors Wu, Bar-Yosef, Goldberg, and Cohen, to conduct a short season of sampling in 2009 in Xianrendong Cave in order to re-date the deposits. As reported in Wu et al. (2012), we reopened previously excavated sections in the Eastern and Western areas to expose profiles to collect samples for micromorphological analyses in order to establish the nature of the deposits and site formation processes (Fig. 3, Fig. 4). We also collected new dating samples from the sections and enhanced this collection with selected bone

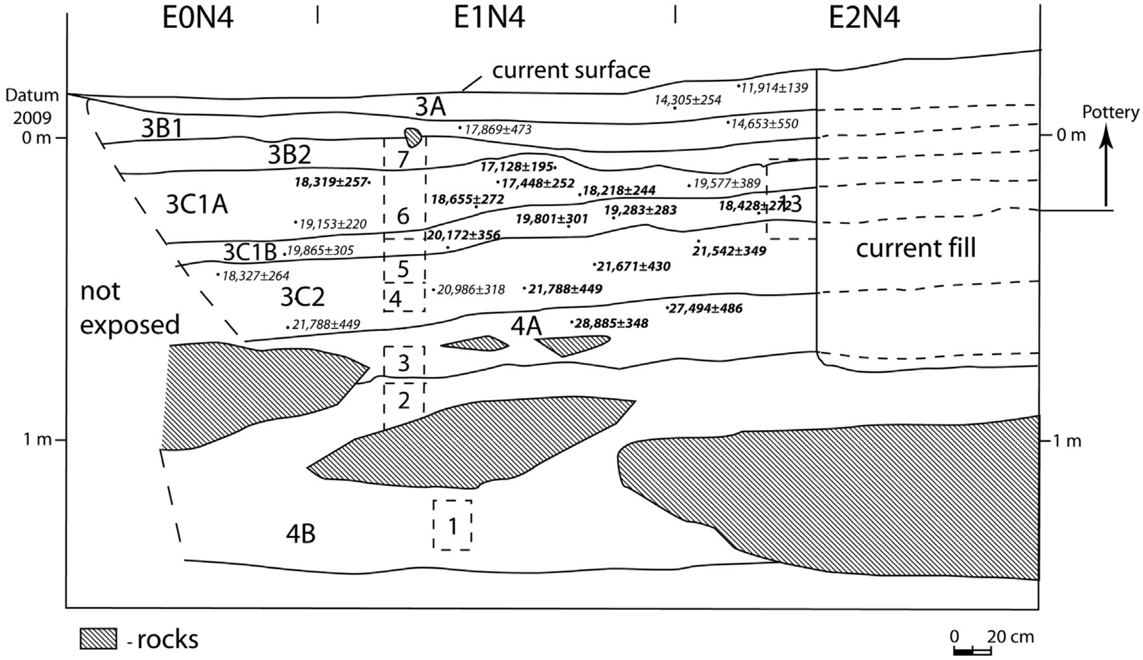

Fig. 3. Western Area profile at Xianrendong Cave exposed during the 2009 excavation, with positions of radiocarbon determinations (from Wu et al., 2012). Hashed rectangular areas are locations of micromorphology block samples 1–7 and 13. The earliest pottery was recovered from layer 3C1B in this area, which is chronologically equivalent to layer 2B in the Eastern Area profile, where the earliest pottery is found in the eastern area of the cave (Fig. 4). These earliest pottery layers can be dated to ca. 20 Ka cal BP.

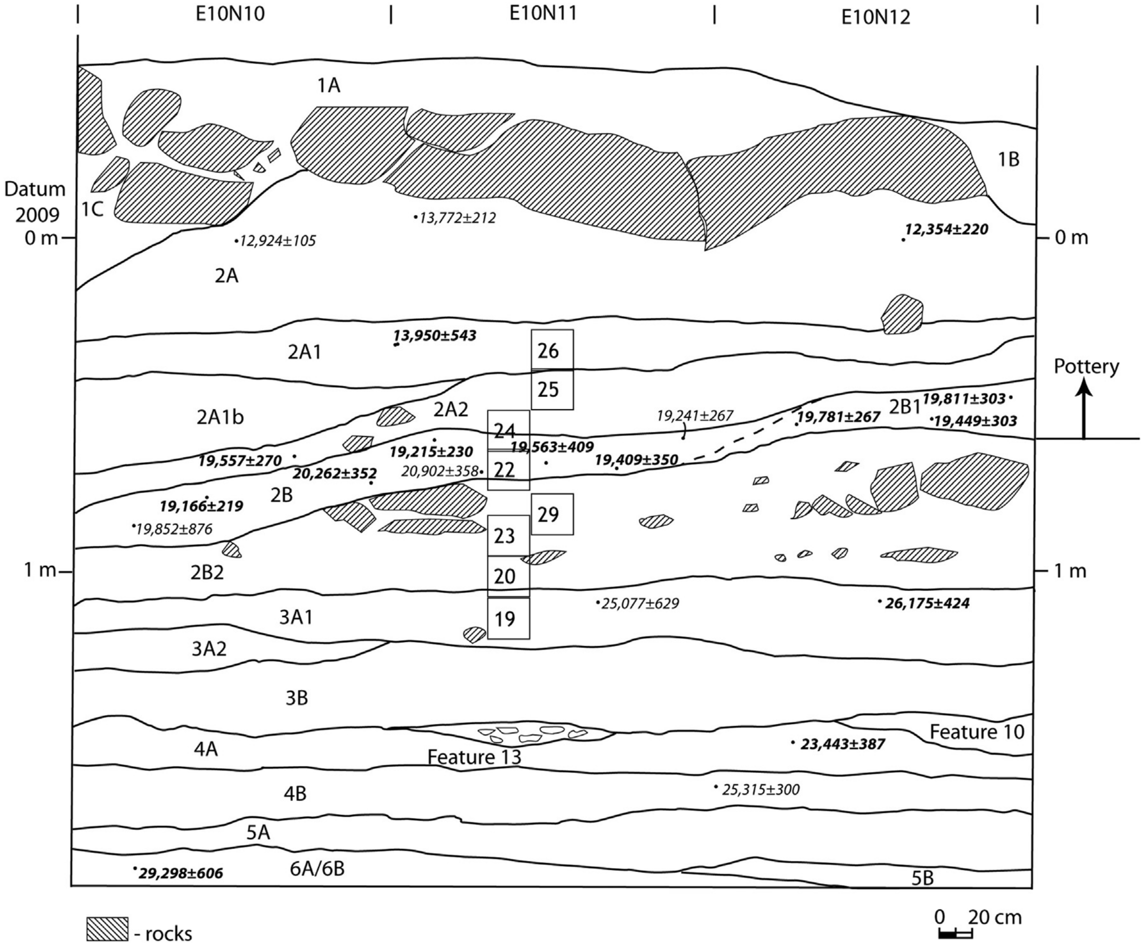

Fig. 4. Eastern Area profile at Xianrendong Cave exposed during the 2009 excavation, with positions of radiocarbon determinations (from Wu et al., 2012). Rectangles are locations of micromorphology block samples 19, 20, 22–26, and 29. The earliest pottery was recovered from layer 2B in this area of the cave, which is chronologically equivalent to layer 3C1B in the Eastern Area profile (Fig. 3). These earliest pottery layers can be dated to ca. 20 Ka cal BP.

samples from the faunal assemblages of the various units from the 1993, 1995, and 1999 excavations stored in Peking University (Wu et al., 2012). This operation did not include any additional digging of new excavation units, and only blocks of sediments, a few cm deep, were removed for micromorphological thin sections from the profiles; these did not contain any pottery fragments. The lack of pottery in the small sample blocks is not surprising as the overall density of pottery sherds in the cave is quite low, as can be seen in the low number of pottery sherds recovered during the previous excavations, with 12 sherds in the earliest potter-containing layers, 3C1B (Western Area) and 2B1 (Eastern Area), in all squares excavated in the 1993, 1995, and 1999 excavations (Peking University and Jiangxi Province, 2014, p. 87).

As described above, when MacNeish established his chronology for Xianrendong in the 1990s (MacNeish et al., 1998), he rejected the majority of the radiocarbon determinations from the excavations, for incorrect reasons, because he felt they were "too early." Instead, MacNeish selectively chose a small number of what today are easily recognized as outlier dates if they are considered amongst the entirety of dated samples from the site. He chose to use these dates and ignore the others because they matched his preconceptions for the dating of the early pottery: he simply ignored the great majority of the dates because they were older than he thought they should be. The re-dating of Xianrendong reported in Wu et al. (2012) clearly demonstrates that the "too early" dates for the oldest pottery-containing levels rejected by MacNeish in fact truly reflect the actual age of these layers and the pottery in them, which we dated to ~20–19 Ka cal BP.

Kuzmin (2013, 2015), however, attempts to argue that MacNeish was correct in rejecting the many "early" determinations in favor of a small number of outlier "younger" dates, but his reasoning is faulty. Kuzmin (2015, p. 3) argues that "age-depth reversals are common at this site", but his support of this is weak. What he means by "reversals" is that three dates from the entire sequence appear to be out of order in terms of their dates and stratigraphical positions, and he thus assumes that this can only be explained by major disturbances in the layers of the site which would have inverted some of the deposits or caused major movements of the dated samples post-depositionally. We should also point out that Xianrendong has an incredible 45 radiocarbon determinations available, so three samples would not be representative of a "common" occurrence. Even more importantly, among the three dates he cites, two are from several layers (3B1 and 3B2) above the early pottery levels, so even if there were "reversals" here, they have no bearing on the early pottery layers below. Also, these two samples, BA09318 and UCR5361, cannot be said to both be out of sequence because they are in order next to each other—at most, one could be out of sequence: if you reject one of them, the other falls into the remaining sequence, particularly if you take into account that BA093181 is a charcoal date and could therefore be subject to the "old wood" problem, meaning that its date is too old due to either the age of the tree itself or the length of time that the wood was available for use before being deposited at the site (this is why animal bone or short-lived plant samples provide more reliable radiocarbon dates). Kuzmin also cites UCR3300 in 3C2, which is some 2–3000 calibrated years younger than the other 4 samples in this layer below the earliest pottery. Kuzmin does not mention that this sample is a human bone fragment. Since it is human bone and there were burial features in upper levels at the cave, this invites the possibility that the excavators may have missed an intrusive burial feature that possibly cut into this layer, thereby excavating it as part of layer 3C2 and not recognizing it as a separate feature, perhaps due to the small area excavated. Layer 3C2 is reported as being up to 76 cm thick in places (Peking University School of Archaeology and Jiangxi, 2014, p. 17), and was not subdivided. Also, as we mentioned above, layers such as 3C2 were defined in such a way that they were thought to extend across the entirety of the West Area as one stratigraphic unit, and were excavated as such, and so there is no detailed reporting on small features, substrata, or lenses.

Kuzmin's argument also ignores the fact that the Eastern Area dates for the earliest pottery layers and the rest of the sequence mirror those in the Western Area, so there is consistency across the two separate areas of the site. Kuzmin (2015, p. 4) also writes that there is a "lack of association" between bone samples collected in 2009 and the pottery, but again, the associations in 2009 are exactly the same as they were in the 1990s: the bone samples and the pottery come from the same stratigraphic contexts, which the original excavators defined by their level and sublevel system, and this was followed in 2009. Another major weakness with Kuzmin's argument—and this one is key— is that he completely ignores the micromorphological analysis of the Xianrendong deposits and tries to base his argument for stratigraphic problems solely on a few radiocarbon dates without even looking at the geoarchaeology of the contexts of the samples—i.e., the stratigraphy itself—which was a central feature of the Xianrendong study by Wu et al. (2012).

The micromorphological analysis of the Xianrendong thin sections shows that the overall stratigraphic contexts from which the samples came were stable and not subject to "age-depth reversals" as Kuzmin would like to believe. The analysis also helps to show why a few of the samples can be rejected as outliers, rather than rejecting the great majority of samples, as Kuzmin wants to do (Wu et al., 2012) (Tables 1 and 2).

Table 1
Radiocarbon determinations from Xianrendong Western Area (after Wu et al., 2012).

Layer	Lab-no.	14C date[a]	Calibrated age range yr BP 1σ[b]	Material	Calibrated age BP 1σ[b]	
2A	BA09891	10210 ± 50	11774–12053	bone	11,914 ± 139	
3A	BA09894	12240 ± 55	14050–14559	bone	14,305 ± 254	
3B1	BA093181	14610 ± 290	17395–18342	ch	17,869 ± 473	[c]
3B2	UCR3561	12420 ± 80	14302–15003	human bone	14,653 ± 350	[c]
3C1A	BA09872	14235 ± 60	17448–17700	bone	17,448 ± 252	
3C1A	BA09868	14925 ± 70	17974–18462	bone	18,218 ± 244	
3C1A	BA09875	13885 ± 55	16933–17333	bone	17,128 ± 195	
3C1A	BA09874	15165 ± 55	18061–18576	bone	18,319 ± 257	
3C1A	BA00006	15655 ± 194	18655–19200	bone	18,928 ± 272	
3C1A	UCR3562	16010 ± 70	18932–19373	human bone	19,153 ± 220	[c]
3C1A	BA95143	16340 ± 200	19187–19966	ch	19,577 ± 389	[c]
3C1B[d]	BA10264	16165 ± 55	19030–19536	bone	19,283 ± 253	
3C1B[d]	BA10266	16485 ± 55	19500–20102	bone	19,801 ± 301	
3C1B[d]	UCR3439	16730 ± 120	19659–20270	ch	19,965 ± 305	[c]
3C1B[d]	BA00007	16915 ± 186	19821–20533	bone	20,177 ± 356	

(*continued on next page*)

Table 1 (*continued*)

Layer	Lab-no.	14C date[a]	Calibrated age range yr BP 1σ[b]	Material	Calibrated age BP 1σ[b]	
3C1B[d]	AA15005	17420 ± 130	20459–21285	ch	20,867 ± 318	c
3C1B[d]	UCR3440	18520 ± 140	21784–22455	ch	22,120 ± 335	c
3C2	UCR3300	15180 ± 90	18062–18591	human bone	18,327 ± 264	c
3C2	UCR3522	17580 ± 80	20668–21304	ch	20,986 ± 318	c
3C2	BA09878	17915 ± 80	21192–21891	bone	21,542 ± 349	
3C2	BA00008	17983 ± 177	21326–22042	bone	21,671 ± 430	
3C2	BA93182	18110 ± 270	21337–22237	ch	21,788 ± 449	c
4A	BA00009	22902 ± 322	27008–27980	bone	27,294 ± 486	
4A	BA09880	24080 ± 95	28507–29263	bone	28,885 ± 378	

Radiocarbon Laboratory; BA-Peking University radiocarbon laboratory; UCR-University of California, Riverside; AA-NSF-Arizona AMS Laboratory, Tucson, Arizona.
ch-charcoal sample.

[a] Using Libby half-life.

[b] Calibration was done using CalPal-HULU.2007 version, 1-Standard Deviation.

[c] Dates cited by MacNeish et al., 1998.

[d] Layer with earliest pottery in this section.

Table 2
Radiocarbon determinations from Xianrendong Eastern Area (after Wu et al., 2012).

Layer	Lab no.	14C date[a]	Calibrated age range cal yr BP 1σ[b]	Material	Calibrated age cal yr BP 1σ[b]	
2A	BA00004	10456 ± 118	12134–12574	bone	12,354 ± 220	
2A	BA95138	11840 ± 150	13560–13984	ch	13,772 ± 212	c
2A1	UCR3558	11020 ± 60	12871–13032	human bone	12,927 ± 105	c
2A1	BA99038	11840 ± 380	13406–14493	bone	13,950 ± 543	
2A2	BA09899	16330 ± 65	19286–19827	bone	19,557 ± 270	
2A3	BA95139	16110 ± 140	18979–19514	ch	19,247 ± 267	c
2B1[d]	BA10263	16030 ± 55	18947–19385	bone	19,166 ± 219	
2B1[d]	BA09912	16495 ± 60	19508–20114	bone	19,811 ± 303	
2B[d]	BA09902	16095 ± 65	18983–19443	bone	19,215 ± 230	
2B[d]	BA10268	16270 ± 65	1913819759	bone	19,449 ± 310	
2B[d]	BA00015	16301 ± 157	19148–19849	bone	19,499 ± 350	
2B[d]	BA99037	16330 ± 220	19153–19972	bone	19,563 ± 409	
2B[d]	BA09926	16345 ± 70	19313–19848	bone	19,581 ± 267	
2B[d]	BA95141	16580 ± 260	19481–20234	ch	19,858 ± 376	c
2B[d]	BA10271	17105 ± 60	20115–20819	bone	20,467 ± 352	
2B[d]	BA95140	17460 ± 210	20543–21260	ch	20,902 ± 358	c
3A	BA95142	20940 ± 440	24448–25706	ch	25,077 ± 629	c
3A	BA09921	21820 ± 85	25751–26599	bone	26,175 ± 424	
4	BA00003	19634 ± 186	23046–23820	bone	23,433 ± 387	
4	BA95144	21090 ± 660	24415–26215	ch	25,315 ± 900	c
6B	BA 99039	24500 ± 370	28691–29904	bone	29,298 ± 606	

Radiocarbon Laboratory; BA-Peking University radiocarbon laboratory; UCR-University of California, Riverside.
ch-charcoal sample.

[a] Using Libby half-life.

[b] Calibration was done using CalPal-HULU.2007 version, 1-Standard Deviation.

[c] Dates cited by MacNeish et al., 1998.

[d] Layer with earliest pottery in this section.

Micromorphological analyses show that the deposits in the Western Area were formed by low energy alluvial processes (slackwater deposition), and are consistently composed of compact sediments. Low porosity and the absence of pedality and bioturbation signal that artifacts and radiocarbon samples recovered from the early pottery layers were not displaced post-depositionally. The Eastern Area, where most of the anthropogenic material is found, contains slightly more evidence for bioturbation and diagenesis. However, it is important to underline that this bioturbation is not prevalent and that it occurs only on a small scale: disruption of the matrix due to insect passages are never larger than 9 mm in diameter and are not pervasive enough to support any hypothesis of mixing of sediments or translocation of objects and charcoal, and particularly of radiocarbon samples of the size that we selected, which was over 1 cm. Continuing analysis of the micromorphology since 2012, to be described in detail in a paper in preparation, supports our conclusions in Wu et al. (2012), that post-depositional disruption of the sediments at any given time was very low. These observations confirm the inference that the bulk of the radiometric dating samples published in 2012 (Wu et al., 2012) were in fact in place and not moved post-depositionally, as Kuzmin would like to believe.

The dates that Kuzmin believes do not fit the sequence should have been explained by the original excavators in combination with more details of the exact excavation contexts, but MacNeish et al. (1998), never did this in their reports, and we can only offer an explanation based on our observations. The date BA 093181 was probably derived from layer 3B2 and not 3B1, a mistake that could be attributed to the same color of sediments that prevailed in this area. The rest of the dates, distributed over deposits that are hardly 50 cm thick, cluster between ~22.5 Ka cal BP and ~17.7 Ka cal BP. We should note that the dates of layer 3C2, where no pottery fragments were noted, fall within the range of most of the dates of the layer above it (3C1B), ~21.78–18.3 Ka cal BP.

Finally, we should note that most of the human bone remains recorded by MacNeish et al. (1998; Table 7) were found in the Western Area and date to the Terminal Pleistocene. The three human bone fragments from the Eastern Area are dated to the Holocene. This supports the information about the removal of the upper layers during the 1962 and 1964 excavations.

In the Eastern section the overall thickness of the early pottery-bearing layers is about 20–30 cm, with sherds found clustered in layers 2A2, 2B1, and 2B2. The dates range between 20.9 and 19.5/19.0 Ka cal BP. The bone dates are slightly younger than the charcoal dates, so we took the most conservative approach to dating the onset of pottery making by using the younger dates for determining the age of the pottery, and we concluded that pottery making would have begun by 20/19,000 cal BP.

What did this pottery made during the Last Glacial Maximum by hunter-gatherers at Xianrendong look like? The pottery was made in two ways (Zhang, 2002a, 2002b). The first technique was a form of slab construction in which the potter joined sheets of clay together in layers extending upward to form the vessel walls. The vessel surfaces were either decorated with parallel striations (called "stripe-marked" by the excavators) formed by scraping a tooth-edged tool across the interior and exterior, or had plain surfaces, resulting from hand smoothing after scraping (Fig. 5). Vessels of this manufacturing technique were the earliest uncovered, with sherds found in layers 3C1B and 3C1A in the Western Area. Rim sherds of both plain and stripe-marked pottery could be decorated with regularly spaced U- or V-shaped notches, and several rows of irregularly spaced punctates appear under some rims formed by punching a stylus into the exterior surface, which caused raised dots on the interiors, as well.

The second manufacturing technique, coiling and paddling, occurred later in the sequence. Coiled pottery was tempered with quartzite or even crushed pottery sherds, and the exterior surfaces and rarely the interior are covered by impressions similar to cord-marking, which appears to have been applied by a paddle wrapped in cordage or fibers: this is found in layer 3B2 and above (MacNeish et al., 1998; Zhang, 2002a, 2002b; Wu et al., 2012; Peking University and Jiangxi Province, 2014). This description also fits the finds from Diaotonghuan Cave, where the number of radiocarbon dates is very small: Diaotonghuan's earliest pottery, from Zone D (zone is the designation for the layers), likely should date to the same period as the early Xianrendong pottery-bearing deposits (Peking University and Jiangxi Province, 2014, p. 196).

In addition, it is important to remark that the dated stratified contexts at Xianrendong and Diaotonghuan (MacNeish et al., 1998) indicate that the caves were occupied intermittently by foragers over a period of up to 17 millennia. The first use of these caves occurred around 28 Ka cal BP, and these are only seen in the Eastern Area of Xianrendong and Zone K in Diaotonghuan. Pottery making began in layers 3C1B in the Western Area and in layer 2B1 in the Eastern Area at Xianrendong. The dates for these earliest pottery layers of ca. 20/19 Ka cal BP coincide with the warming phase at the end of the LGM, when monsoon precipitation increased in the region. The two caves were abandoned during the Heinrich 1 cold event (*ca.* 16.5–15.0 Ka cal BP) (see Wang et al., 2002; on a speleothem record for South China; Wang et al., 2012; on southern China lake sediments pollen), were re-occupied sometime later from 14 to 12 Ka cal BP (Bølling-Allerød through the Younger Dryas), and then were deserted at the onset of the Holocene.

Subsistence activities at Xianrendong have not been studied in great detail. Studies of rice phytoliths at the site show changing patterns of wild plant exploitation, represented mainly by rice phytoliths, by hunter-gatherers at the cave (Zhao, 1998). Hunted game, evidenced by bone fragments, include mostly the remains of one deer species (*Cervus nippon*) and smaller amounts of bones of other deer species (*Muntiacus* sp., *Moschus* sp., and *Hydropotes inermis*), but there have been no taphonomic studies done of the bone, and such studies remain limited in China (for examples, see Lam et al., 2010; Prendergast et al., 2009). Second in abundance to deer, but less than the three deer species, is wild boar, and there was a minimal presence of several carnivores and a few rodents (Peking University and Jiangxi Province, 2014). In addition, the lithic industry in the early pottery layers is of the cobble tool type, typical of the South China Late Paleolithic, in which chopper-chopping tools are found together with bone and antler objects with polishing (including awls, points, barbed points, spades, scrapers), and large *Unio* shell tools, many with central perforations (Peking University and Jiangxi Province, 2014). The late cobble tool assemblages in South China, such as at Xianrendong and Yuchanyan, which begin ca. 24 Ka cal BP, continue out of Pleistocene core and flake and then cobble tool industries and likely coincide with the extent of bamboo forests in this region and extending into Southeast Asia (Bar-Yosef, 2015): one hypothesis for why this conservative lithic industry persists in South China is that chopping

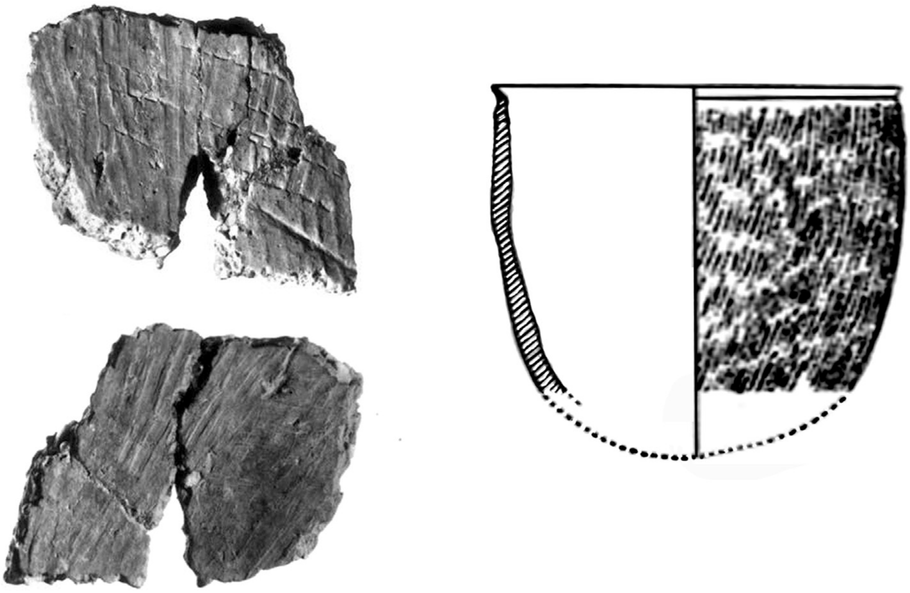

Fig. 5. Early pottery from Xianrendong Cave. Left: "Stripe-marked" pottery sherd from Layer 3C1b dating to ~20–19 Ka cal. BP. Right: A reconstruction of the possible appearance of an early pottery vessel. Images courtesy of the *Origins of Rice Cultivation in the Yangzi River Basin Project*; after Wu et al. (2012, Supplement).

tools and flakes may have been used to fashion more complex tools and cutting edges on bamboo or other organic materials (Bar-Yosef et al., 2012). The stone tools that are found in the early pottery contexts are the same as those found throughout southern China in the wide-ranging cobble tool tradition, and include one-sided choppers, heavy-duty choppers, and flakes, more similar to Lower and Middle Pleistocene assemblages than to Upper Paleolithic stone tools in western Eurasia, while there are also examples of unique types such as perforated cobbles (perhaps used on digging sticks) and cobbles with "cupholes" (possibly used for cracking nuts or processing pigments) (Bar-Yosef, 2015; Qu et al., 2012).

2.2. Yuchanyan (Hunan Province)

Yuchanyan Cave is located in Daoxian County, Hunan, some 450 km south of the Yangzi River. It is a karstic cavity in one of the "sugar cone" hills in this karst region that stretches west into Guangxi Province, where the cave of Zengpiyan is located. Excavations were first conducted in 1993 and 1995, and again by a Sino-American team in two seasons, in 2004 and 2005 (Yuan, 2000, 2002, 2013). The upper part of the deposits in the cave had been removed by local farmers previous to the excavations, and in addition, several historical burials were dug into the existing upper layers of the prehistoric accumulations. However, the rest of the layers were not affected by post-depositional disturbances, except for minimal rodent activity.

The 1990s excavations recovered two clusters of sherds from which a conical-shaped pottery cauldron and a large fragment of a second vessel could be reconstructed. The 2004–5 excavations found two additional sherds in the same layer where the earliest pottery fragments were previously discovered (layer 3H). An extensive dating project carried out during the 2004–5 excavations seasons focused on the northern area, where the preserved deposits are about 1 m thick and where the pottery fragments were recovered (Boaretto et al., 2009) (Fig. 6). The stratigraphic distribution of the dates (Table 3) indicates that most of the occupational sequence, likely made up from seasonal visits by hunter-gatherers, took place after the LGM.

Micromorphological and mineralogical studies of the Yuchanyan deposits show that they are mainly anthropogenic (rather than formed by natural karstic activity in the cave as has often been assumed at other cave sites in China without further testing) (Fig. 7). These deposits consist of ash, charcoal, and bone, suggesting that humans built wood fires in the cave and likely used them for cooking (based on faunal remains). The deposits include several *in situ* fire features as well as many lenses composed of the remains of fires.

From a preliminary micromorphological analysis, horizontal deposits of allochthonous red kaolinite clay, which had to be

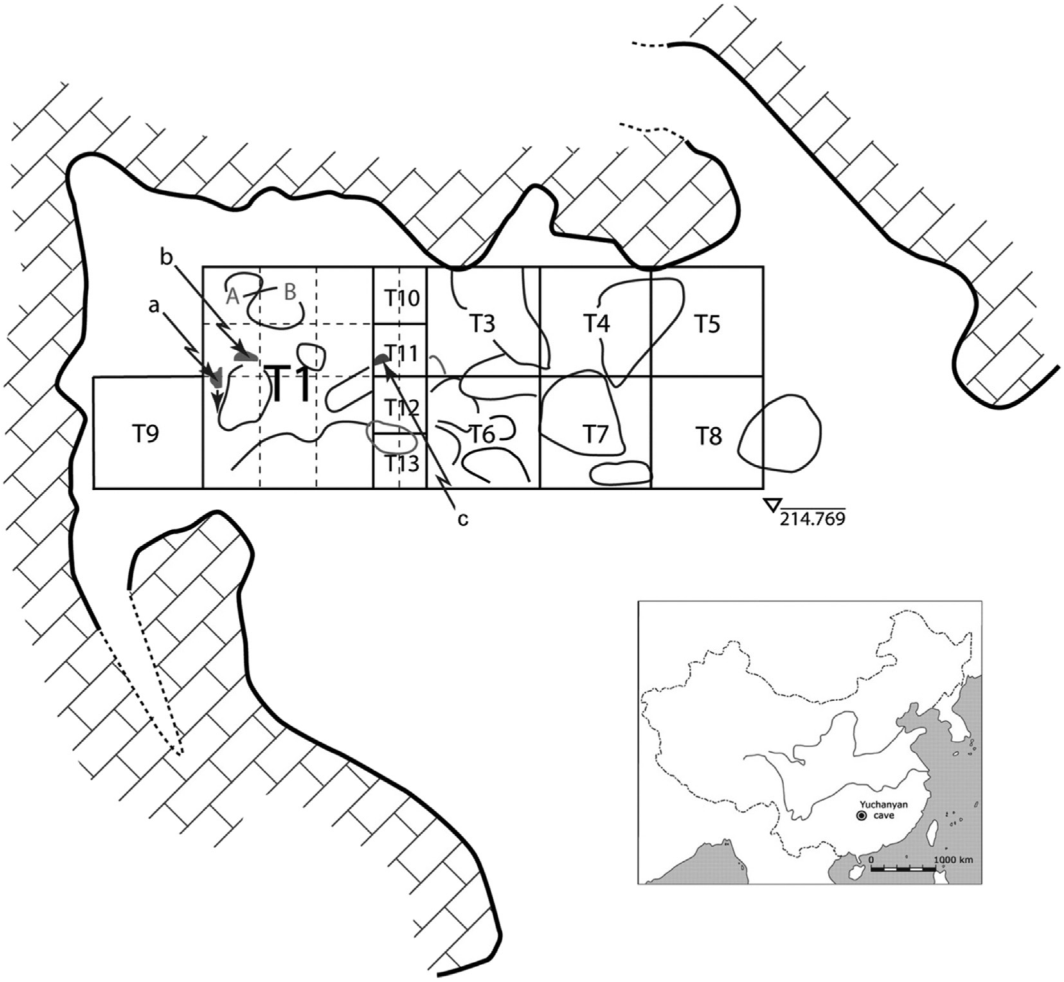

Fig. 6. Plan of Yuchanyan Cave, Hunan, showing the excavation grid from the various expeditions, and (inset) position of Yuchanyan Cave in China. a, b, c mark locations of early pottery sherds (from Boaretto et al., 2009).

Table 3
Uncalibrated (Libby date) and calibrated radiocarbon dates of all the samples analyzed at Yuchanyan Cave, Hunan (Boaretto et al., 2009). The samples are ordered by stratigraphic depth. The results from the western section (T9, T1, T10-T12) are in stratigraphic order, and are followed by those from the upper layers in the eastern section (T5), which was about 5 m distant from the western section in the cave. All of the radiocarbon dates were calibrated with OxCal 3.10.

Weizmann Institute number	PKU Lab number	Material dated		^{14}C age±1σ year BP	Calibrated age ±1σ year BP	Calibrated age ±2σ year BP
RTT 3967	**Average**	charcoal	T9, west section, 129 cm	12190 ± 85	14020–13850	14090–13790
RTT 3968				11970 ± 90		
				12089 ± 62		
RTT 3966		charcoal	T9, west section, 135 cm	11975 ± 85	13940–13750	14030–13670
RTT 3969		charcoal	T9, west section, 190 cm	12230 ± 85	14210–13960	14600–13800
RTB 5117	BA05429a	bone	T9, west section, 191m	12100 ± 70	14210–13850	14650–13750
RTB 5117	BA05429b			12275 ± 50		
	Average			**12188 ± 124**		
RTT 3970		charcoal	T9, west section, 194 cm	11865 ± 85	13820–13630	13920–13480
RTB 5208	BA05898-1	bone	T10a, 3A, 195 cm	12440 ± 40	14490–14190	14750–14100
RTB 5208	BA05898-2			12350 ± 40		
	Average			**12395 ± 28**		
RTB 5113	BA05425a	charcoal	T1, south, 198 cm	12290 ± 50	14180–14050	14250–13990
RTB 5113	BA05425b			12230 ± 50		
	Average			**12260 ± 35**		
RTB 5112	BA05424a	charcoal	T1, south, 204 cm	12360 ± 50		14650–14050
RTB 5112	BA05424b			12345 ± 60	14380–14130	
	Average			**12348 ± 33**		
RTB 5205	BA05895-1	charcoal	T11a, 3A IV, 217 cm	11670 ± 40		13620–13370
RTB 5205	BA05895-2			11600 ± 40		
	Average			**11635 ± 28**	13540–13410	
RTB 5206	BA05896-1	charcoal	T10a, 3A, 219 cm	11860 ± 40	13780–13700	13820–13650
RTB 5206	BA05896-2			11870 ± 40		
	Average			11865 ± 28		
RTB 5207	BA05897-1	charcoal	T1c, 3BIII, 228 cm	12020 ± 40	13930–13810	13980–13780
RTB 5207	BA05897-2			12020 ± 40		
	Average			**12020 ± 28**		
RTB 5209	BA05899	bone	T10c, 3B III, 230 cm	12400 ± 40	14580(6.7%)14530 14500(61.5%)14200	14800–14100
RTB 5204	BA05894-1	charcoal	T11a, 3C, 236 cm	12200 ± 40	14650–14000	14950–13850
RTB 5204	BA05894-2			12430 ± 40		
	Average			**12315 ± 163**		
RTB 5110	BA05422	charcoal	T1D-c, layer: 3E, 251 cm	13890 ± 50	16760–16340	16950–16150
RTB 5107	BA05419a	charcoal	T1E, layer: 3E, 251 cm	12835 ± 40	15250–15020	15400–14940
RTB 5107	BA05419b			12815 ± 60		
	Average			**12829 ± 33**		
RTB 5108	BA05420	charcoal	T1E, layer: 3E, 254 cm	11855 ± 50	13790–13670	13840–13580
RTB 5109	BA05421	charcoal	T1A, layer: 3E, 255 cm	12735 ± 70	15170–14910	15350–14700
RTB 5114	BA05426	bone	T1E, layer: 3E, 253–258 cm	13425 ± 70	16140–15740	16400–15550
RTB 5465	BA06865	bone	T11a, layer: 3FH, 252 cm	14695 ± 55	17990–17700	18050–17350
RTB 5463	BA06863	charcoal	T11c, layer: 3H, 255 cm	14610 ± 55	17900–17510	18000–17150
RTB 5466	BA06866	bone	T11c, layer: 3H, 257 cm	14835 ± 60	18500(14.1%)18350 18200(54.1%)17850	18550–17750
RTB 5464	BA06864	charcoal	T11c, layer: 3H, 260 cm	14800 ± 55	18080–17800	18500–17650
RTB 5470	BA06867	charcoal	T12a, layer: 3H, 260 cm	14795 ± 60	18500(13.3%)18420 18390(54.9%)18100	18600–18000
RTB 5115	BA05427	bone	T1E, layer: 3I, 260–264 cm	17720 ± 90	21110–20700	21300–20550
RTB 5111	BA05423a	charcoal	T5, east, 222 cm	12260 ± 60	14160–14040	14230–13980
RTB 5111	BA05423b			12235 ± 50		
	Average			**12245 ± 38**		
RTB 5116	BA05428	bone	T5, east, 229 cm	12315 ± 60	14370–14070	14650–14000
RTB 5471	BA06868	charcoal	T5, 305–314 cm	12825 ± 50	15250–15010	15420–14920

brought into the cave by humans as there is no natural source area nor depositional mechanism for them to accumulate. These layers are found between the lenses of wood ash in a few locations, and since they are not found beneath any extant surfaces, these horizontal bands of clay likely represent purposefully prepared clay surfaces. Lenses of ash from wood fires overlie these clay surfaces, and infrared spectra show that some of these clay bands had reached temperatures between 400 and 500 °C (Boaretto et al., 2009), so they were possibly used in cooking or parching.

The construction of prepared clay surfaces is a documented behavior in several Late Pleistocene and early Holocene sites. Some of these have been investigated using micromorphology. In the cave site of Klisoura in Greece, clay was used to line fire-pits and create a surface onto which nuts and other plant material could be roasted (Karkanas et al., 2004). Clay surfaces also were constructed in Native American sites during the Early Holocene. For example, clay surfaces at the Icehouse Bottom (Tennessee) and Dust Cave (Alabama) sites have both been analyzed using micromorphology (see Sherwood et al., 2004; Sherwood and Chapman, 2005). In these two sites, the clay surfaces were also connected to fire features and were subject to multiple firing temperatures. At Yuchanyan, a complete study of the micromorphology and geoarchaeology of the cave is still ongoing, and this will lead us to a fuller understanding of the context of these surfaces at Yuchanyan within the greater discussion of human activities within the cave.

While Xianrendong pottery remains were limited to sherds, Yuchanyan early pottery includes a reconstructable vessel and a large fragment of a second vessel, so it provides the earliest

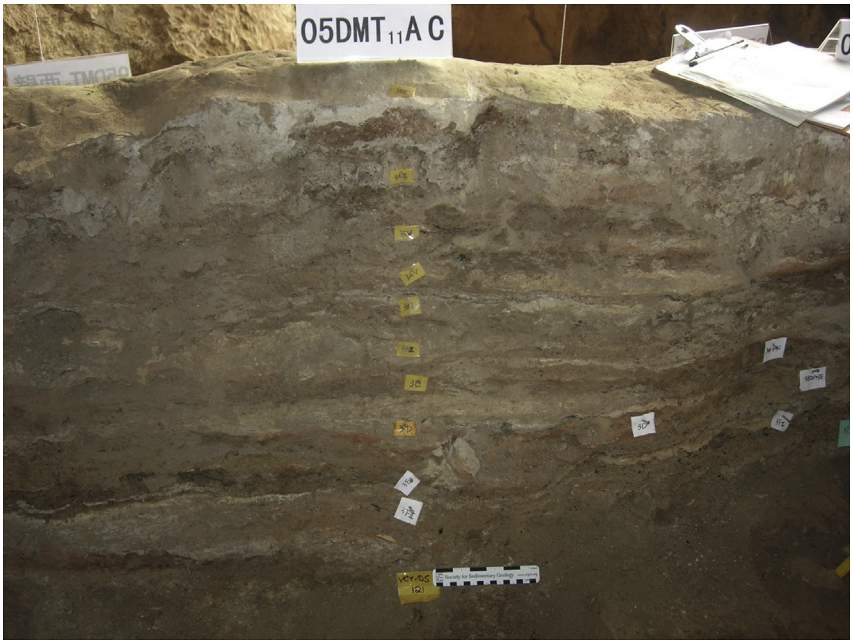

Fig. 7. Profile at Yuchanyan Cave in square T11, subsquares A-C, as exposed in 2005, showing lenses of calcitic ash and reddish clay. One pottery sherd was found embedded in this sequence. Scale bar is 15 cm.

evidence for a complete vessel form. The pottery is crumbly and coarsely made with thick, uneven walls up to two cm thick. The clay matrix has inclusions of charcoal, crushed quartz, and water-polished pebbles up to 5 mm in size. The pottery was fired at moderate temperature, perhaps 600 °C. The one reconstructed vessel, in the shape of a cauldron, was formed by attaching slabs of clay together (Fig. 8). It is conical in shape with a pointed base, stands 29 cm high, and opens to a mouth diameter of 31 cm. The interior and exterior surfaces of this vessel and the other pottery fragment appear to be impressed with cordage (Boaretto et al., 2009; Yuan, 2002, 2013).

Fig. 8. The reconstructed pottery vessel from Yuchanyan Cave. This cauldron-shaped vessel stands 29 cm tall and has a mouth diameter of 31 cm. Image courtesy of the *Origins of Rice Cultivation in the Yangzi River Basin Project*.

Yuchanyan deposits, like those in Xianrendong, are rich in cervid remains including sambar, Pere David deer, water deer, muntjak, musk deer, and sika deer, as well as many aquatic birds (Prendergast et al., 2009). Deer, by the amount of bone remains, provided most of the meat, and breakage patterns may indicate processing for maximal grease and marrow extraction. Some of the waterfowl were migratory species that can be used as indicators of seasonal occupations by humans at the site in the winter.

Combined with evidence for seasonal occupations, the extensive series of radiocarbon dates from Yuchanyan (Boaretto et al., 2009) allows us to see repeated human presence and gaps in the occupational sequence of the cave, with an early or natural deposition at ca. 20 Ka cal BP, an occupation at ca. 18 Ka cal BP when the pottery was produced, and then briefer occupation periods at ca. 16 and 15.5 to 14.5 Ka cal BP. Most of the preserved deposits date to 14.3 through 13.8 Ka cal BP, which corresponds to a warming period in East Asia equivalent to the Bølling-Allerød. As the top layers are missing, it is difficult to affirm when the cave was abandoned.

3. Conclusions

The presence of pottery made by hunter-gatherers long before the Neolithic Revolution challenges the old concept accepted by many schools since the days of Gordon Childe that pottery is tied to sedentism and agricultural production (Jordan and Zvelebil, 2009). The presence of pottery in Late Pleistocene Upper Paleolithic contexts in South China (and elsewhere in East Asia) well before the sedentary sites of plant-cultivating groups of the Neolithic appear in the early Holocene raises the question that is in many ways easier to answer when we are dealing with farming communities— what purpose did early pottery serve? In Early Neolithic village sites, pottery is ubiquitous and can be seen to fill many roles in sedentary domestic activities, such as food and beverage preparation, cooking, and storage. But in the more ephemerally occupied Late Paleolithic cave sites of hunter-gatherers in South China, with only small amounts of pottery found, we are still at a preliminary place in our understanding of its roles, and as expected, the answers to this question offered in the literature, are numerous and still far from conclusive. Most prefer to see these rare occurrences of mostly individual pots (or more often, a few remaining sherds of a pot) in the earliest phases of pottery production as employed as kitchen equipment. Their rarity immediately motivated some scholars to see them as produced for use in special circumstances, rather than for daily use, especially in feasting (e.g., Hayden and Villeneuve, 2011), and if this is the case, the early pottery had an important social and perhaps ideological function, much more so than just being a utilitarian object.

In China, there have been no formal studies of the early pottery remains from the earliest cave sites yet, and so we have little evidence as to their use. Residue analysis is still in its infancy in East Asia but could perhaps offer some interesting results, as it has in a few studies of Jōmon pottery. Craig et al. (2013) demonstrate through analysis of lipids in pottery residue that a series of Jōmon vessels from 15 to 11.8 ky cal BP were used almost exclusively for cooking marine and freshwater organisms. Another Japanese example recently published demonstrates through molecular and isotopic analyses of lipid residues from 143 vessels recovered in the 9000-year sequence from Torihama, a Jōmon site in western Japan, that this role of pottery continues there as well, with the pottery predominantly used for cooking marine and freshwater resources (Lucquin et al., 2016), with almost no indications of terrestrial animal or plant processing. Given the different continental, inland ecozones of the South China sites, we should expect that the pottery at Xianrendong and Yuchanyan was used for cooking other foods, and the rich faunal record at Yuchanyan (with a predominance of various species of deer, as well as waterfowl) and how the animals were processed, particularly for grease extraction, may offer some clues (see Prendergast et al., 2009).

As the amounts of pottery produced, the diversity of its forms, and the dispersal patterns of pottery change through time (with pottery becoming more widespread across regions and more prevalent at individual sites), so, too, perhaps, do the roles of pottery. Therefore, to understand the invention of pottery during the Terminal Pleistocene and its dispersal and adoption, we must consider its contexts and scales of use across not only different time periods, but also at the regional, inter-site, and intra-site level. Also necessary to consider is that during the same time when a few early pots were made, there were other, contemporary sites within the local region without pottery: why was pottery used at some sites but not others of similar size and with similar cultural assemblages? Pearson (2005), who examined the phenomenon of early pottery in South China sees no evidence of social differentiation as a cause for the new technology of pottery, but also argues that pottery could be used for feasting as markers of a collective event for building social cohesion. For South China, we need to continue to build models for testing the use and roles of early pottery and to apply more analytical methods to understand the properties and use of recovered pottery remains.

Understanding the roles of pottery in South China, as elsewhere, will take a number of steps, and we are at the earliest stages of this process. First, there must be excavations with careful stratigraphic controls and reconstruction of the formation processes of the pottery-containing contexts. Second, the pottery must be well dated, and this would typically involve dating its stratigraphic contexts, as at Xianrendong and Yuchanyan, and testing the reliability of the dating samples and security of their contexts, such as through micromorphology. There must be physical and chemical studies of the pottery, including residue analyses as well as use-wear, petrographic, and firing studies, among others, and experimental studies to understand pottery production and use. The more data that can be brought to bear on understanding the roles of early pottery, the better our understanding will become, and we are currently only at the start of this process.

References

An, Z., 1991. Radiocarbon dating and the prehistoric archaeology of China. World Archaeology 23, 193–200.

Bar-Yosef, O., 2015. Chinese Paleolithic challenges for interpretations of Paleolithic archaeology. Anthropologie LIII, 77–92.

Bar-Yosef, O., Eren, M.I., Yuan, J., Cohen, D.J., Li, Y., 2012. Were bamboo tools made in prehistoric Southeast Asia? An experimental view from South China. Quaternary International 269, 9–21.

Bellwood, P., 2005. First Farmers: the Origins of Agricultural Societies. Wiley-Blackwell, Malden, MA.

Boaretto, E., Xiaohong, Wu, Yuan, J., Bar-Yosef, O., Chu, V., Pan, Y., Liu, K., Cohen, D., Jiao, T., Li, S., Gu, H., Goldberg, P., Weiner, S., 2009. Radiocarbon dating of charcoal and bone collagen associated with early pottery at Yuchanyan Cave, Hunan Province, China. Proceedings of the National Academy of Sciences USA 106 (24), 9595–9600.

Buvit, I., Terry, K., 2011. The twilight of Paleolithic Siberia: Humans and their environments east of Lake Baikal at the late-glacial/Holocene transition. Quaternary International 242, 379–400.

Chen, S., 1999. Excavations and research on the Miaoyan cave site in Guilin. In: Yingde Museum, Zhongshan University Anthropology Department, Guangdong Provincial Museum (Ed.), Essays from the Symposium on Mesolithic Cultures and Related Issues, Guangdong Renmin Chubanshe, Guangzhou, China, pp. 150–165 (in Chinese).

Childe, V.G., 1936. Man Makes Himself. Watts and Co., London.

Chu, V., Regev, L., Weiner, S., Boaretto, E., 2008. Differentiating between anthropogenic calcite in plaster, ash and natural calcite using infrared spectroscopy: implication in archaeology. Journal of Archaeolgical Science 35, 905–911.

Cohen, D.J., 2011. The beginnings of agriculture in China: a multi-regional view. Current Anthropology 52, S273–S293.

Cohen, D.J., 2013. The advent and spread of early pottery in East Asia: new dates and new considerations for the world's earliest ceramic vessels. Journal of Austronesian Studies 4 (2), 55–92.

Courty, M.-A., Goldberg, P., Macphail, R.I., 1989. Soils and Micromorphology in Archaeology. Cambridge University Press, Cambridge.

Craig, O.E., Saul, H., Lucquin, A., Nishida, Y., Taché, K., Clarke, L., Thompson, A., Altoft, D.T., Uchiyama, J., Ajimoto, M., Gibbs, K., Isaksson, S., Heron, C.P., Jordan, P., 2013. Earliest evidence for the use of pottery. Nature 496, 351–354.

Crawford, G.W., 2011. Advances in understanding early agriculture in Japan. Current Anthropology 52 (S4), S331–S345.

Fujian Provincial Museum and Longyan City Culture and Publications Bureau, 2013. Preliminary report for the Qihedong prehistoric site in Zhangping city, Fujian. Kaogu 2013 (5), 7–19 (in Chinese).

Gibbs, K., Jordan, P., 2016. A comparative perspective on the 'western' and 'eastern' Neolithics of Eurasia: Ceramics; agriculture and sedentism. Quaternary International (in press).

Hayden, B., Villeneuve, S., 2011. A century of feasting studies. Annual Review of Anthropology 40 (1), 433–449.

Institute of Archaeology, Chinese Academy of Social Sciences, 2003. Guilin Zengpiyan. Cultural Relics Publishing House, Beijing (in Chinese).

Jordan, P., Zvelebil, M., 2009. *Ex Oriente Lux*: the prehistory of hunter-gatherer ceramic dispersals. In: Jordan, P., Zvelebil, M. (Eds.), Ceramics Before Farming: the Dispersal of Pottery Among Prehistoric Eurasian Hunter-Gatherers. Left Coast Press, Walnut Creek, CA, pp. 33–89.

Kaner, S., 2009. Long-term innovation: the appearance and spread of pottery in the Japanese archipelago. In: Jordan, P., Zvelebil, M. (Eds.), Ceramics Before Farming: the Dispersal of Pottery Among Prehistoric Eurasian Hunter-Gatherers. Left Coast Press, Walnut Creek, CA, pp. 93–119.

Karkanas, P., Koumouzelis, M., Kozlowski, J.K., Sitlivy, V., Sobczyk, K., Berna, F., Weiner, S., 2004. The earliest evidence for clay hearths: Aurignacian features in Klisoura Cave 1, southern Greece. Antiquity 78, 513–525.

Kudo, Y., 2012. Emergence of pottery in the Japanese archipelago and its environmental context. Quaternary International 279–280, 258.

Kuzmin, Y.V., 2013. Origin of Old World pottery as viewed from the early 2010s: when, where and why? World Archaeology 45 (4), 539–556.

Kuzmin, Y.V., 2015. The origins of pottery in East Asia: updated analysis (the 2015 state-of-the-art). Documenta Praehistorica XLII, 1–11.

Lam, Y.M., Brunson, K., Meadow, R., Yuan, J., 2010. Integrating taphonomy into the practice of zooarchaeology in China. Quaternary International 211, 86–90.

Li, Z., Kunikita, D., Kato, S., 2016. Early pottery from the Lingjing site and the emergence of pottery in northern China. Quaternary International (in press).

Liuzhou Museum, 1983. The Liyuzui shell mound site in Dalongtan, Liuzhou City. Kaogu 1983 (9), 1–11 (in Chinese).

Lu, T., 2010. Early pottery in South China. Asian Perspectives 49 (1), 1–42.

Lucquin, A., Gibbs, K., Uchiyama, J., Saul, H., Ajimoto, M., Eley, Y., Radini, A., Heron, C.P., Shoda, S., Nishida, Y., Lundy, J., Jordan, P., Isaksson, S., Craig, O.E., 2016. Ancient lipids document continuity in the use of early hunter–gatherer pottery through 9,000 years of Japanese prehistory. Proceedings of the National Academy of Sciences USA 113 (15), 3991–3996.

MacNeish, R.S., 1999. A Paleolithic–neolithic sequence from South China Jiangxi Province, PRC. In: Omoto, K. (Ed.), Interdisciplinary Perspectives on the Origins of the Japanese. International Research Center for Japanese Studies, Kyoto, pp. 233–255.

MacNeish, R.S., Cunnar, G., Zhao, Z., Libby, J.G., 1998. Re-revised Second Annual Report of the Sino-American Jiangxi (PRC) Origin of Rice Project (SAJOR). Andover Foundation for Archaeological Research, Andover, MA.

Noshiro, S., Kudo, Y., Sasaski, Y., 2016. Emergence of prehistoric management of plant resources during the incipient to initial Jomon periods in Japan. Quaternary International (in press).

Pearson, R., 2005. The social context of early pottery in the Lingnan Region of South China. Antiquity 79, 819–828.

Peking University School of Archaeology and Museology, Jiangxi Province Cultural Relics and Archaeology, 2014. Xianrendong and Diaotonghan. Cultural Relics Publishing House, Beijing (in Chinese).

Peng, S., Zhou, G., 2006. The Xianrendong and Diaotonghuan sites in Wannian, Jiangxi: a research case on the modeling of the Paleolithic to Neolithic transition (in Chinese). In: Institute of Archaeology, CASS (Ed.), South China and Southeast Asian Region Prehistoric Archaeology: Essays from the Symposium in Honor of the 30th Anniversary of the Zengpiyan Excavations. Cultural Relics Publishing House, Beijing, pp. 102–115 (in Chinese).

Prendergast, M.E., Yuan, J., Bar-Yosef, O., 2009. Resource intensification in the Late Upper Paleolithic: a view from southern China. Journal of Archaeological Science 36, 1027–1037.

Qu, T., Bar-Yosef, O., Wang, Y., Wu, X., 2012. The Chinese Upper Paleolithic: Geography, chronology, and techno-typology. Journal of Archaeological Research 21, 1–73.

Sato, H., Izuho, M., Morisaki, K., 2011. Human cultures and environmental changes in the Pleistocene–Holocene transition in the Japanese archipelago. Quaternary International 237, 93–102.

Schiegl, S., Lev-Yadun, S., Bar-Yosef, O., El Goresy, A., Weiner, S., 1994. Siliceous aggregates from prehistoric wood ash: a major component of sediments in Kebara and Hayonim caves (Israel). Israel Journal of Earth Sciences 43, 267–278.

Schiegl, S., Goldberg, P., Bar-Yosef, O., Weiner, S., 1996. Ash deposits in Hayonim and Kebara Caves, Israel: macroscopic, microscopic and mineralogical observations, and their archaeological implications. Journal of Archaeological Science 23, 763–781.

Sherwood, S.C., Chapman, J., 2005. The identification and potential significance of early Holocene prepared clay surfaces: examples from Dust Cave and Icehouse Bottom. Southeastern Archaeology 24, 70–82.

Sherwood, S.C., Driskell, B.N., Randall, A.R., Meeks, S.C., 2004. Chronology and stratigraphy at Dust Cave, Alabama. American Antiquity 69 (3), 533–554.

Sun, J., Zhan, K., 2004. Snow white rice grains were first grown from here: the Xianrendong and Diaotonghuan Sites in Wannian. In: Sun, J., Zhan, K. (Eds.), Civilization Under the Trowel: Important Archaeological Discoveries in Jiangxi. Jiangxi Peoples Press, Nanchang, Jiangxi, China, pp. 1–43 (in Chinese).

Svoboda, J., Hladilová, Š., Horáček, I., Kaiser, J., Králík, M., Novák, J., Novák, M., Pokorný, P., Sázelová, S., Smolíková, L., Zikmund, T., 2015. Dolní Věstonice IIa: Gravettian microstratigraphy, environment, and the origin of baked clay production in Moravia. Quaternary International 359–360, 195–210.

Tsydenova, N., Piezonka, H., 2015. The transition from the Late Paleolithic to the Initial Neolithic in the Baikal region: Technological aspects of the stone industries. Quaternary International 355, 101–113.

Wang, Y., Wu, J., Liu, D., Wu, J., Cai, Y., Cheng, H., 2002. A quick cooling event of the East Asian monsoon responding to Heinrich Event 1: evidence from stalagmite δ^{18}O records. Science in China (Series D) 45 (1), 88–96.

Wang, S., Lu, H., Han, J., Chu, G., Liu, J., Negendank, J.F.W., 2012. Palaeovegetation and palaeoclimate in low-latitude southern China during the Last Glacial Maximum. Quaternary International 248, 79–85.

Wang, Y., Zhang, S., Gu, W., Wang, S., He, J., Wu, X., Qu, T., Zhao, J., Chen, Y., Bar-Yosef, O., 2015. Lijiagou and the earliest pottery in Henan Province, China. Antiquity 89 (344), 273–291.

Wu, X., Zhang, C., Goldberg, P., Cohen, D., Pan, Y., Arpin, T., Bar-Yosef, O., 2012. Early pottery at 20,000 Years ago in Xianrendong Cave, China. Science 336, 1696–1700.

Yoshida, K., Kunikita, D., Miyazaki, Y., Nishida, Y., Miyao, T., Matsukazi, H., 2013. Dating and stable isotope analysis of charred residues on the Incipient Jomon pottery (Japan). Radiocarbon 55 (2–3), 1322–1333.

Yuan, J., 2000. Rice grains and pottery from over 10,000 years ago at Yuchanyan, Daoxian, Hunan. In: Yan, W., Yasuda, Y. (Eds.), The Origins of Pottery and Cities. Cultural Relics Publishing House, Beijing, pp. 31–49 (in Chinese).

Yuan, J., 2002. Rice and pottery 10,000 yrs. BP at Yuchanyan, Dao County, Hunan Province. In: Yasuda, Y. (Ed.), The Origins of Pottery and Agriculture. Roli Press, New Delhi, pp. 157–166.

Yuan, J., 2013. Hunan Paleolithic Cultures and the Yuchanyan Site. Yuelu Publishers, Changsha, Hunan, China (in Chinese).

Zhang, C., 2002a. Early pottery and rice phytolith remains from Xianrendong and Diaotonghuan Sites, Wannian, Jiangxi Province. In: Yasuda, Y. (Ed.), The Origins of Pottery and Agriculture. Roli Press, New Delhi, pp. 185–191.

Zhang, C., 2002b. The discovery of early pottery in China. Documenta Praehistorica 29, 29–35.

Zhao, Z., 1998. The middle Yangtze region in China is one place where rice was domesticated: phytolith evidence from the Diaotonghuan cave, northern Jiangxi. Antiquity 72 (278), 885–897.

Zhushchikhovskaya, I.S., 2009. Pottery-making in prehistoric cultures of the Russian Far East. In: Jordan, P., Zvelebil, M. (Eds.), Ceramics Before Farming: The Dispersal of Pottery Among Prehistoric Eurasian Hunter-Gatherers. Left Coast, Walnut Creek, CA, pp. 121–147.