RADIOCARBON DATING OF CHARRED RESIDUES ON THE EARLIEST POTTERY IN JAPAN

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ABSTRACT. Recently, primitive-type pottery was discovered in the Russian Far East, China, and Japan. Radiocarbon ages of far earlier than 10,000 BP have been obtained, relating directly or indirectly to the pottery. As an example of these very old ^{14}C ages for incipient pottery, we report here ^{14}C ages of charred adhesions on five potsherds and three charred wood fragments that were collected with the archeological artifacts (stone tools from the Chojakubo Culture) in the loam layers at the Odai Yamamoto I site (41°03′44″N, 140°33′20″E) in Aomori prefecture, at the northern end of the Japanese main island. The carbonaceous remains on the surface of the potsherds could be ancient food residues or soot from fuel for cooking. These small carbon samples were dated at the Tandetron accelerator mass spectrometry (AMS) ^{14}C dating facility at Nagoya University, as well as by Beta Analytic Co. Ltd. Except for two charred wood ^{14}C dates, 7070 ± 40 and 7710 ± 40 BP, all five charred-residue samples and one wood charcoal sample gave older ^{14}C ages of 12,680–13,780 BP, corresponding to the period of the Chojakubo Culture in Japan. This culture marks the beginning of the Jomon Culture, which is characterized by pottery usage and bow-and-arrow hunting.

INTRODUCTION

Two radiocarbon ages by a gas-proportional-counter system, 12,700 ± 500 (Gak-949) and 12,400 ± 350 BP (Gak-950), were obtained for charcoal samples from Layer III and the layer immediately above it, Layer II, where Jomon pottery fragments of the oldest type were discovered during the 1960 excavation of Fukui Cave in the Nagasaki prefecture, Kyushu Island, Japan. The dates came as a great surprise to Japanese archeologists because at that time the pottery had been thought to originate no earlier than the beginning of the Holocene, 10,000 BP. Recently, several primitive-type pottery fragments have been discovered in Russian Far East, China and Japan, and their ^{14}C ages more than 10,000 BP have been obtained (O'Malley et al. 1999).

Two kinds of samples—indirect and direct—are available for determination of ^{14}C ages of pottery. Indirect samples are carbonaceous residues collected from the sites. For example, charcoal fragments that were carefully collected from the same layer where the potsherds were discovered. This kind of sample is easily collected and commonly used for ^{14}C dating. However, the relation between the charcoal fragments and the potsherds is not evident. We sometimes obtain ^{14}C ages of carbon residues that obviously contradict the archeological age as determined by pottery style or form. Most often, the ^{14}C ages are younger.

Direct ^{14}C dating of pottery itself can be done with AMS, using carbonaceous fractions extracted physically and chemically from the surface or inside of potsherds. These materials are: 1) an organic-rich coating on potsherds, such carbon as from fuel or food, or 2) organic temper inside potsherds, which is included intentionally during pottery production. However, the materials composing the potsherds may contain carbon in advance of pottery production. For example, clays may have contained appreciable amounts of carbon, which could have remained in the pottery even after it was heated to several hundred degrees centigrade during production. This kind of carbon may provide the age of soil formation or before. In addition, secondary carbon contamination may be present, such as absorption on the surface of potsherds of humic acids, fluvic acids, and lipids from the sur-

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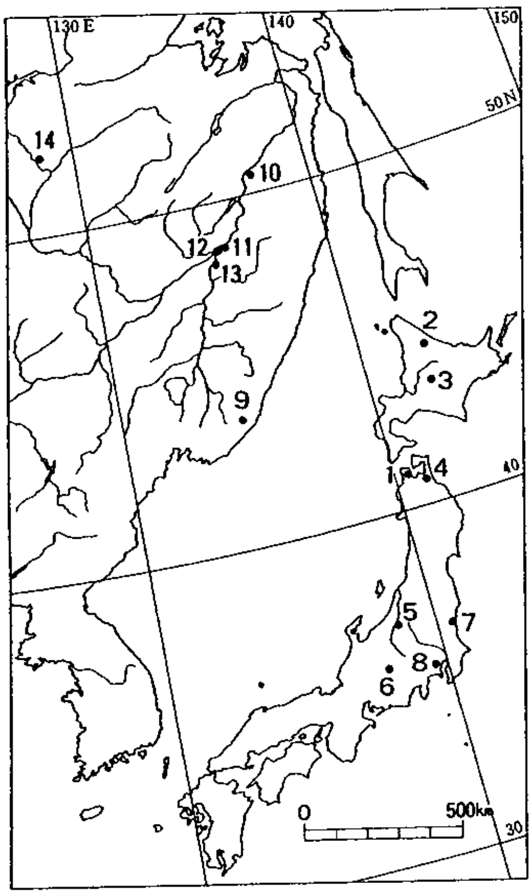
rounding soils. All these organic fractions are younger than the potsherds, with apparent ^{14}C ages depending on the turnover time of organic matter (Gabasio et al. 1986; Hedges et al. 1992).

^{14}C dating of charred remains on the surface of potsherds in Japan has been tried successfully, providing ^{14}C ages consistent with archeological estimates (Nakamura and Iwahana 1990; Nakamura et al. 1990). In fact, Hedges (1992) concluded that an organic-rich coating on the potsherds, such as from fuel or food, provides a fairly reliable sample. Recently, O'Malley et al. (1999) presented a stepwise heating technique to extract only a temper carbon fraction from interior and exterior parts of potsherds, and obtained preliminary ^{14}C ages for pottery from Russian Far East.

We report here the results of AMS ^{14}C dating of charred adhesions on five potsherds and three wood charcoal fragments collected together in the loam layers at the Odai Yamamoto I site.



Japanese sites
1. Odai Yamamoto I
2. Mosanru
3. Higashirokugo 2
4. Chojakubo
5. Jin
6. Mikoshiba
7. Ushirono A
8. Terao

Russian sites
9. Ustinovka
10. Khummy
11. Gasya
12. Osipovka
13. Goncharka 1
14. Gromatukha

Figure 1 Locations of archeological sites in the period of primitive-type-pottery production in Japan and the Russian Far East.

SITE LOCATION AND SAMPLING

The Odai Yamamoto I site is located at the northern end of the main island, Honshu, in Japan (41° 03′44″N, 140°33′20″E; see Figure 1). The site is located on a low terrace on the left bank of the Kanita River, on the eastern side of the Tsugaru Peninsula. Its altitude is about 26 m, about 11 m above the floodplain of the present river. The Odai Yamamoto II and III sites are located nearby, being 135 m away at most from the Odai Yamamoto I site. According to the excavation studies of the sites so far performed, it is realized that these three sites have been occupied during the end of Paleolithic, at the time of the microblade and projectile point cultures, and during Incipient Jomon, the time of Chojakubo culture (Odai Yamamoto I site excavation team 1999).

The Odai Yamamoto I site first caught the attention of archeologists when a Mikoshiba-type partially ground stone ax was collected accidentally by a junior high school student on the ground surface at the site in 1971. Following the first discovery of the stone tool, the Aomori Prefectural Museum conducted the full excavation at the site in 1975 and 1976. These excavations yielded typical Chojakubo-type stone artifacts thought to be from Paleolithic culture (at that time), together with 32 potsherds of plain (mumon)-type pottery with a flat bottom and two arrow heads; both are distinctive of Jomon culture. These findings had considerable repercussions on the question of the origin or beginning of pottery technology in the Japanese Islands. These 1975 and 1976 excavations unearthed a total of 91 m^2 at the site.

The 1998 excavation of the Odai Yamamoto I site was conducted from July 1 to 16. The sedimentary stratigraphy can be basically divided into 8 strata (I, IIa, II, IIIa, III, IV, V, and VI, in descending order), including the base layer (VI) made of gravel (Odai Yamamoto I site excavation team 1999). Several artifacts belonging to the Chojakubo phase, the beginning of the Incipient Jomon Period, were found concentrated in Stratum III, a yellowish-tan volcanic loam, and extending below that into Stratum IV, a light yellowish-brown sandy-silty loam. These strata yielded 262 stone artifacts and 46 potsherds. All of these artifacts were found in an area only 10 m in diameter, forming a very clear, single-point-in-time assemblage.

The potsherds are all from the same vessel. Though the vessel cannot be fully reconstructed, it should have a flat base and was either a deep bowl or a pot, with no clear surface decoration. The wall thickness was 7.6 mm and the clay had no fiber tempering. Carbonized materials remained on the surface of 30 potsherds. Some of the remains on the inner surface formed a water level line. This indicates that the vessel was used for boiling various kinds of food (Taniguchi 1999).

The Odai Yamamoto II site, about 130 m east from the Odai Yamamoto I site, was excavated in 1977, 1978, and 1989 by the Aomori Prefectural Museum, and more than 2500 Paleolithic stone tools were collected from definite stratigraphic layers. The Odai Yamamoto III site, about 135 m north of the Odai Yamamoto I site, was excavated in 1979 by the Aomori Prefectural Museum, and several paleolithic stone tools were collected. No potsherds were discovered, however, at the Odai Yamamoto II or III sites.

METHODS

Of the 46 potsherds excavated, 11 with carbon adhesions on their surfaces were selected and delivered to the AMS facility of Nagoya University. Among them, 5 potsherds whose surface was covered more abundantly with carbon adhesions were selected for ^{14}C dating. In addition, 10 pieces of small wood charcoal fragments were sent to the National Museum of Japanese History, where 3 charcoal pieces were selected for ^{14}C dating and sent to the Beta Analytic Co. Ltd. The wood fragments were checked of their original species by the anatomical characteristics with a microscope.

At the Center for Chronological Research, Nagoya University, carbon adhesions were removed from each of the 5 potsherds by using a blade. At that time, a small part of soil composing the potsherds inevitably mixed into charred materials used for ^{14}C analysis. Purification and CO_2 extraction from the carbonaceous samples, graphite target production, and AMS ^{14}C dating were performed at Nagoya University, according to Nakamura et al. (1985) and Nakamura (1995). We describe the procedures briefly. The samples were treated twice with 1.2 M HCl for 2 hr at 80 °C to remove any possible carbonate contaminants. Next, the samples were treated with 0.2 M NaOH solution for 2 hr at 80 °C, which is weaker in concentration than those alkaline solutions used routinely for normal samples with abundant carbon, in order to limit the loss of carbon and to obtain sufficient carbon for precise ^{14}C dating from the originally small carbon samples. The samples were treated again with 1.2 M HCl for 2 hr at 80 °C. To remove HCl component completely from those small samples, centrifuge and decant were repeated after adding some distilled water.

The samples were then dried in an electric oven at 90 °C. The weight of the pretreated sample is given in Table 1. For the very small sample F5-017, we added a few hundred-milligrams of CuO powder as a carrier to the sample in the centrifuge tube, to collect carbonaceous materials completely. The total amount of pretreated charred samples was used to produce CO_2. The samples were placed in Vycor tubes of about 350 mm in length and 9 mm in outer diameter, with about 500 mg of granular CuO. Then the tubes were connected to a vacuum line, evacuated completely, and sealed to a tube length of 300 mm. The Vycor tubes were heated to 900 °C for 2 hr to completely convert carbon to CO_2. The CO_2 produced was purified cryogenically in a vacuum line and reduce to graphite on about 2 mg Fe powder in the presence of hydrogen. The amount of collected CO_2 is given in Table 1. The graphite materials were pressed into aluminum target holders for AMS ^{14}C dating. We used the Hox-II standard (NIST oxalic acid, RM-49) as a ^{14}C-concentration reference. Alliquots of CO_2 for samples E4-036 and E4-048 were used for $\delta^{13}C_{PDB}$ measurements with an ordinary mass spectrometer (Finnigan MAT-252). The measured values of $\delta^{13}C_{PDB}$ for E4-036 and E4-048 were used for carbon-isotopic-fractionation correction to sample ^{14}C concentrations. An average value of $\delta^{13}C_{PDB}$ for E4-036 and E4-048 was used for F5-017, D4-005, and E4-030, whose $\delta^{13}C_{PDB}$ values were not measured because their carbon yields were rather limited and accurate ^{14}C dating was the first priority. Finally, the ^{14}C ages calculated by using the Libby's half life of 5568 yr, were calibrated to a calendar scale, using the CALIB 4.0 program (Stuiver and Reimer 1993) with INTCAL98 calibration data (Stuiver et al. 1998).

Table 1 Characteristics of charred adhesion samples on potsherds, analyzed for ^{14}C dating at Nagoya University. Sampling horizon, material, weight of samples after pretreatment, CO_2 yield from pretreated samples.

Sample #	Horizons of collecting potsherds	Material dated	Weight of charred deposits after AAA pretreatment (mg)	Yield of carbon (carbon content; mg, weight %)
F5-017	IV-layer	Charred deposits	Not measured	0.67 (not measured)
D4-005	III-layer	Charred deposits	13.50	0.76 (5.6%)
E4-036	Lower of III-layer	Charred deposits	36.40	3.08 (8.5%)
E4-030	Lowest of III-layer	Charred deposits	14.45	0.71 (4.9%)
E4-048	Uppermost of IV-layer	Charred deposits	34.06	2.04 (6.0%)

RESULTS AND DISCUSSION

^{14}C Ages of Incipient Pottery at the Odai Yamamoto I Site

The ^{14}C ages as well as calibrated dates for five charred adhesion and three charcoal samples are give in Table 2. According to Taniguchi (1999), all of the collected potsherds are from one vessel. This fact suggests that 5 potsherds should show similar ^{14}C ages. However, the ^{14}C ages for charred adhesions ranged from 12,680 ± 140 to 13,780 ± 170 BP, with a rather large variation width of 1100 yr. Of course, carbon sources of charred adhesions can be different, being dependent on the position of deposits. For example, food residues may have produced charred materials on both the

Table 2 ^{14}C ages and calibrated ages of charcoal remains on the surface of pottery fragments discovered at the Ohdai-Yamamoto I site, Aomori prefecture, Japan

Sample #	Horizons	Sample material and its position	$\delta^{13}C_{PDB}$ (‰)	^{14}C age[a] (BP ± 1σ)	Calibrated age using INTCAL98 upper: intercept[b] (mid.) lower: ±1σ range and probability	Lab code[c]
F5-017	IV-layer	Charred remains on the outer wall of the pottery	—[d]	13,780 ± 170	cal BP 16,540 cal BP 16,850–16,240 (100%)	NUTA-6510
D4-005	III-layer	Charred remains on the inner wall of the pottery	—[d]	13,210 ± 160	cal BP 15,880 cal BP 16,220–15,540 (100%)	NUTA-6515
E4-036	Lower of III-layer	Charred remains on the outer wall of the pottery	–30.5	13,030 ± 170	cal BP 15,660 cal BP 16,080–15,260 (100%)	NUTA-6507
E4-030	Lowest of III-layer	Charred remains on the inner wall of the pottery	—[d]	12,720 ± 160	cal BP 15,360 cal BP 15,620–15,150 (47.4%) cal BP 14,780–14,360 (52.6%)	NUTA-6509
E4-048	Uppermost of IV-layer	Charred remains on both inner and outer walls of the pottery	–29.6	12,680 ± 140	cal BP 15,320 cal BP 15,570–15,150 (40.1%) cal BP 14,790–14,350 (59.9%)	NUTA-6506
			Average:	13,070 ± 440	cal BP 15,710 cal BP 16,330–15,160 (85.5%) cal BP 14,680–14,410 (14.5%)	
E5-100	III-layer	Wood charcoal	–26.1	13,480 ± 70	cal BP 16,190 cal BP 16,440–15,950 (100%)	Beta-125550 (RH-130)
E5-011	III-layer	Wood charcoal	–27.0	7710 ± 40	cal BP 8450 cal BP 8520–8500 (32%) cal BP 8480–8420 (68%)	Beta-125551 (RH-131)
E2-100	III-layer	Wood charcoal	–27.2	7070 ± 40	cal BP 7930, 7900, 7870 cal BP 7940–7840 (100%)	Beta-127791 (RH-148)

[a] ^{14}C ages were calculated after the correction of isotopic fractionation. For samples F5-017, D4-005 and E4-030, the average value of the two $\delta^{13}C_{PDB}$ values (E4-036, E4-048) was used.

[b] ^{14}C ages were calibrated to calendar dates using a calibration program Mac CALIB4.0 program and INTCAL98 calibration data. Both intercept and calibrated age ranges (with probabilities) are given.

[c] NUTA: Nagoya University, Beta: Beta Analytic Co. Ltd., RH: National Museum of Japanese History

[d] $\delta^{13}C_{PDB}$ was not measured for this sample, because a rather limited yield of carbon was affordable only for ^{14}C dating.

inner and outer walls, and fuels for cooking furnished soot materials on the outer and bottom walls of the vessel. Charred residue samples D4-005 and D4-030 were collected from the inner wall, F5-017 and E4-036 were from the outer wall, and E4-048 was from both the inner and the outer walls of the pottery. No clear tendency can be seen in the ^{14}C age between charred residues from the inner wall and those from the outer wall (Table 2). Different sources may give relevant ^{14}C ages. However, the difference of 1100 yr is rather large compared with the estimated duration of the pottery usage (several years at most). The soot materials may give us ages of several decades or a few hundred years (but rarely more than hundreds of years) older than the period of the pottery usage because of the old wood effect of woody fuels. No large buried trees were excavated around the site. In addition, we suspect that the large variation in ^{14}C age may depend on how completely the contamination by carbonaceous materials from soils surrounding the potsherds has been removed. Such contaminants from soils are generally younger, depending on the turnover time of carbon materials. Thus the younger ages of the potsherds imply that the removal of contaminants is relatively poor and therefore it is suggested that the older ages are more acceptable. However, since the potsherds are fragments of one vessel, we also can get a good estimate of the ^{14}C age of the pottery by averaging the obtained five dates, resulting in 13,070 ± 440 BP. We expect the ^{14}C age of the pottery usage at the Odai Yamamoto I site to be in the range from the average value 13,070 ± 440 BP to the oldest age 13,780 ± 170 BP.

On the other hand, the ^{14}C ages of charcoal samples ranged from 7070 ± 40 to 13,480 ± 70 BP, with a maximum difference of 6410 yr. The oldest ^{14}C age, 13,480 ± 70 BP, agrees perfectly with the ^{14}C ages of charred adhesions on the potsherds. All the charcoal samples were examined in wood species by a high-resolution optical microscope. Sample E5-100, which showed the oldest age, was identified as a needle-leaf tree. Samples E5-011 and E2-100, which showed younger ^{14}C ages, were identified as *Acer* sp. (maple) and *Cephalotaxus harringtonia* K. Koch (plum-yew). Both trees are constituents of the typical Jomon forest. The former can be a cold climate vegetation, but the latter two charcoal fragments are products of a warmer period and most likely were mixed into the loam layers at the site by later humans or natural agents.

The Chojakubo-type stone artifacts collected together with the potsherds at the Odai Yamamoto I site were also excavated for the first time at the Chojakubo site, Tohoku-cho, Aomori prefecture. The layer including the artifacts at the Chojakubo site was covered by the Hachinohe pyroclastic flow deposit (To-H) to the maximum thickness of 3 m. The ^{14}C ages of the To-H range from 10,400 ± 220 to 13,960 ± 510 BP, with an average value of about 12,600 BP, after more than 20 years of studies (Machida and Arai 1992). We also performed AMS ^{14}C dating of two charred wood trunks directly covered by the To-H, resulting in the ages of 12,640 ± 150 BP (NUTA-2261) and 12,660 ± 150 BP (NUTA-2260) (Terada et al. 1994). Our ^{14}C ages for the Odai Yamamoto I pottery are also consistent stratigraphically with these To-H ages.

^{14}C Ages of Incipient Pottery in Japan and Russian Far East

^{14}C ages of carbon samples related with primitive pottery in Japan as well as in the Russian Far East are summarized in Tables 3a and 3b, respectively. The oldest ^{14}C age of 16,250 ± 180 BP was obtained for charcoal sample collected from the same layer where three small pieces of heated soil blocks that looked like potsherds were discovered. It has been confirmed that one of the soil blocks has been heated up to 500 °C by thermoluminescence analysis (Nagatomo, personal communication 2000), though these pieces are not confirmed yet as parts of pottery.

The pottery fragments of the Odai Yamamoto I site were discovered in association with Chojakubo lithic assemblages. The presence of pottery at the stage of the Chojakubo Culture has been confirmed

Table 3a ^{14}C ages and their calibrated dates of carbon samples related with primitive pottery production in Japan

Pottery type	Archeological site	Horizons and materials dated	^{14}C age (BP)	Calibrated date (cal BP)	Dating method[a]	Lab code[b]
Plain (Mumon)	Shimomouchi site, Nagano Prefecture	Charcoal from IInd culture layer	16,250 ± 180	19,380	^{14}C (AMS)	NUTA-1515
Plain (Mumon)	Odai Yamamoto I site, Aomori Prefecture	Charred deposits on potsherds	13,780 ± 180	16,540	^{14}C (AMS)	NUTA-6510
			13,210 ± 180	15,880	^{14}C (AMS)	NUTA-6515
			13,030 ± 180	15,670	^{14}C (AMS)	NUTA-6507
			12,720 ± 180	15,360	^{14}C (AMS)	NUTA-6509
			12,680 ± 180	15,320	^{14}C (AMS)	NUTA-6506
		Wood charcoal fragment	13,480 ± 70	16,190	^{14}C (AMS)	Beta-125550
Plain (Mumon)	Kitahara site, Kanagawa Prefecture	Wood charcoal from 1st cultural layer	13,060 ± 80	15,700	^{14}C (AMS)	Beta-105398
			9480 ± 80	10,730, 10,720, 10,690	^{14}C (AMS)	Beta-105399
			13,050 ± 80	15,690	^{14}C (AMS)	Beta-105400
			13,060 ± 100	15,700	^{14}C (AMS)	Beta-105401
			13,020 ± 80	15,660	^{14}C (AMS)	Beta-105402
			13,050 ± 80	15,690	^{14}C (AMS)	Beta-105403
Bean-relief (Toryumon)	Senpukuji-Cave site, Nagasaki Prefecture	Heated obsidian	10,800 ± 400	—	FT	—
		Heated pebble	11,840 ± 740[c]	—	TL	—
		Peaty soil	10,300 ± 200	12,270, 12,250, 12,110	^{14}C	—
Linear-relief (Ryukisenmon)	Fukui-Cave site, Nagasaki Prefecture	Charcoal from IIIrd layer	12,700 ± 500	15,340	^{14}C (β)	Gak-949
Linear-relief (Ryukisenmon)	Kami-kuroiwa rock-shelter site, Ehime Prefecture	Charcoal from IVth layer	12,165 ± 600	14,120	^{14}C (β)	I-944
		Charcoal from VIth layer	10,085 ± 320	11,640, 11,610, 11,580	^{14}C (β)	I-943
Nail-marked (Tsumegatamon)	Fukui-Cave site, Nagasaki Prefecture	Charcoal from IInd layer	12,400 ± 350	14,340	^{14}C (β)	Gak-950

[a] ^{14}C: ^{14}C dating, ^{14}C (β): activity measurement, ^{14}C (AMS): AMS measurement, FT: fission track, TL: thermoluminescence.

[b] NUTA: Nagoya University, Gak: Gakushuin University, I: Teledyne Brown Engineering Environmental Services, USA, LE: Institute of the History of Material Culture, Russian Academy of Sciences, T: Norwegian Univ. of Science and Technology, Norway, LLNL: Laurence Livermore National Laboratory AMS facility, USA, AA: NSF-Arizona AMS facility, USA, Beta: Beta Analytic Co. Ltd., USA. (Odai Yamamoto I site excavation team, 1999; O'Malley et al. 1999; Kuzmin et al. 1997; Shevkamud 1997; Kajiwara 1998).

[c] Average of three dates 12,170 ± 1170, 11,980 ± 280, 11,370 ± 760 BP

Table 3b ^{14}C ages and their calibrated dates of carbon samples related with primitive pottery production in Russian Far East

Pottery type	Archeological site	Horizons and materials dated	^{14}C age (BP)	Calibrated date (cal BP)	Dating method[a]	Lab code[b]
Unknown	Khummy site	Lower, charcoal	13,260 ± 100	15,940	^{14}C (AMS)	AA13392
		Upper, charcoal	10,345 ± 110	12,310, 12,220, 12,170	^{14}C (AMS)	AA13391
		?	12,010 ± 105	14,070	^{14}C (AMS)	T 5959
Grooves	Gasya site	Lower, charcoal	12,960 ± 120	15,580	^{14}C (β)	LE-1781
		Lower, ?	11,905 ± 80	14,010, 13,960, 13,840	^{14}C (AMS)	T 5960
		Upper, charcoal	10,875 ± 90	12,920	^{14}C (β)	LE 13393
		Upper, ?	11,340 ± 60	13,310, 13,260, 13,190	^{14}C	GEO 1413
Unknown	Goncharka site	Lower, carbonaceous	12,500 ± 60	15,080, 14,730, 14,380	^{14}C (AMS)	LLNL-102169
		Upper, carbonaceous	10,590 ± 60	12,800, 12,740, 12,650	^{14}C (AMS)	LLNL-102168
		Upper, carbonaceous ?	9890 ± 230	11,230	^{14}C	Gak 18981
Unknown	Gromatukha	?	12,830 ± 120	15,470	^{14}C (AMS)	T 5965
Unknown	Novopetrovka	?	9285 ± 65	10,490, 10,440, 10,430	^{14}C (AMS)	T 5963
		?	11,720 ± 95	13,810	^{14}C (AMS)	T 5964
Unknown	Ust'-Karenga site	Associated charcoal	11,240 ± 180	13,160	^{14}C	GIN 8066
		Associated charcoal	10,750 ± 60	12,870	^{14}C	GIN 8067
		Associated charcoal	12,245 ± 85	14,250, 14,220, 14,160	^{14}C (AMS)	T 5967

[a] ^{14}C: ^{14}C dating, ^{14}C (β): activity measurement, ^{14}C (AMS): AMS measurement, FT: fission track, TL: thermoluminescence.

[b] NUTA: Nagoya University, Gak: Gakushuin University, I: Teledyne Brown Engineering Environmental Services, USA, LE: Institute of the History of Material Culture, Russian Academy of Sciences, T: Norwegian Univ. of Science and Technology, Norway, LLNL: Laurence Livermore National Laboratory AMS facility, USA, AA: NSF-Arizona AMS facility, USA, Beta: Beta Analytic Co. Ltd., USA. (Odai Yamamoto I site excavation team, 1999; O'Malley et al. 1999; Kuzmin et al. 1997; Shevkamud 1997; Kajiwara 1998).

at two other sites: Higashi Rokugo 2 in Hokkaido and Ushirono Loc. A in Ibaragi prefecture. In addition, Chojakubo-like lithic assemblages have been found in association with pottery at the sites: Terao in Cultural Layer I in Kanagawa prefecture, Tanashi Minami-cho in Tokyo, and Tama New Town No. 796 in Tokyo. Thus, the archeological sites having the oldest-type pottery were located in the northeastern part of Japanese Islands, neighboring the Russian Far East, and this may suggest strong cultural exchange and relations between the Japanese Islands and the Russian Far East.

^{14}C ages related to pottery samples discovered at archeological sites in the Amur River drainage, which are geologically close to northeastern Japan, ranged from 11,000 to 13,000 BP (Table 3b) and are consistent with ^{14}C ages of the oldest pottery in Japan. The ^{14}C age data on the primitive pottery in China is not discussed in this paper because we cannot obtain those data easily. We suggest, however, that archeological sites in the Far East should be examined more intensively and carefully to clarify the origin of pottery.

Calibrated Age of the Oldest Pottery and Paleoclimate

Pottery production at the Odai Yamamoto I site dates back as early as 13,070–13,780 BP, and these ^{14}C ages can be calibrated to 15,710-16,540 cal BP with INTCAL98 calibration data (Stuiver et al. 1998). These ages suggest that the first pottery was manufactured earlier than the initiation of the series of climate fluctuations that characterize the final stage of the last glaciation. Stuiver et al. (1995) summarized the eminent climatic fluctuations at the latest part of the last glaciation: Oldest Dryas (started ca. 15,070 cal BP, estimated by ice layer counting), Bølling (14,670 cal BP), Older Dryas (14,090 cal BP), Allerød (14,010 cal BP), Intra-Allerød cold period (13,070 cal BP), Younger Dryas (12,890 cal BP), and Holocene (11,650 cal BP). The Odai Yamamoto I pottery was produced during the cold climate condition, predating such climatic fluctuations by about a millennium. It has been considered that the Jomon Culture, with the first use of pottery in Japan, started in the Holocene after these rapid climatic fluctuations have terminated. However, this view is not consistent with the ^{14}C ages of the Odai Yamamoto I pottery. Thus, a new scheme is necessary to explain the origin of pottery production and the beginning of the Jomon Culture.

CONCLUSION

Several tens of potsherds were collected as fragments of very primitive type pottery, in association with the Chojyakubo lithic assemblages, at the Odai Yamamoto I archeological site. We conducted AMS ^{14}C dating on charred adhesions on 5 pieces of potsherds and 3 wood charcoal fragments collected together with the archeological artifacts in the loam layers. The charred materials on the surface of the potsherds could be ancient food residues or fuel carbon for cooking and can provide the ^{14}C age of the pottery usage. The ^{14}C age of charred adhesions on potsherds ranged from 12,680 to 13,780 BP, with average value of 13,070 ± 440 BP. We estimate that the age of the Odai Yamamoto pottery can be assigned as 13,070–13,780 BP, and calibrated age as 15,710–16,540 cal BP, using INTCAL98 calibration data. This age belongs to one of the oldest ages obtained so far for pottery samples discovered in Japan and Russian Far East.

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