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Technology and Resource Use during the Early Upper Palaeolithic on the Japanese Islands

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ABSTRACT

This paper explains changes in lithic assemblages during the Early Upper Palaeolithic (EUP) on the Musashino Upland through quantitative comparisons of the selection of lithic raw materials, core reduction, and formal tool production. The results suggest that transformations in aspects of lithic assemblage variability could be explained by shifts in raw materials usage, not developments (i.e., the sophistication of tool-making skills) in blade technology and methods of formal tool production. The findings also imply that modifications in lithic raw materials usage would have been affected by changes in organic raw materials usage in entire technological systems, as well as alterations in the territorial scale of foraging and the residential mobility of EUP hunter-gatherers in relation to shifting environmental settings during the EUP. These modifications in lithic assemblages, associated with the changes in human behaviour regarding technological adaptations are thought to reflect early modern humans' flexibility, as well as their dispersal across Eurasia.

INTRODUCTION

Behavioural modernity in early modern humans has been studied mainly based on data from Europe, Western Asia, and Africa; art, body ornaments, bone tools, long-distance exchanges of raw materials, blade technology, and artefacts styles are included in this body of data (e.g., Mellars 1989; McBreaty and Brooks 2000; Conard 2008). On the other hand, recent archaeological research in the other regions (such as Southeast Asia and Australia) reveals a different aspect of early modern humans' behavioral modernity. Archaeologists have found evidence of new behaviour in these regions, such as adaptive behaviour in tropical rainforests, sea sailing, and advanced maritime skills (Barker et al. 2007; O'Connor et al 2011; Hiscock 2015; Roberts and Amano 2019). These results demonstrate early modern humans' technological flexibility as hunter-gatherers. In the 1980s, L. R. Binford assumed that flexible abilities related to the techno-adaptive strategies were a main aspect of modern behavioural traits. This assessment was based on an understanding of modern hunter-gatherers' techno-adaptive strategies (Binford 1989). He explained that hunter-gatherers' techno-adaptive strategies in various environmental settings arose from planning depth, tactical depth, and curation, which are strongly linked to a group's mobility. Data from the Early Upper Palaeolithic (EUP) in the Japanese Islands provide excellent examples of early modern humans' technological flexibility of in response to environmental variables. Specifically, these sites show drastic changes in lithic assemblages, along with shifts in environmental conditions during the EUP. In this paper, the author explains several contexts, introduces a case study from the Japanese EUP, and finally discusses the implications of the findings.

CONTEXTS

1) The Palaeoenvironment of the Japanese Islands during Marine Isotope Stages (MIS) 3 and 2

The Japanese Islands consist of many smaller islands and four main ones: Hokkaido, Honshu, Shikoku, and Kyushu (Figure 1). During MIS 3 and 2, Hokkaido was a part of a large peninsula formed by the development of land bridges between Hokkaido, Sakhalin, the Kurile Islands, and the Russian Far East. Honshu, Shikoku, and Kyushu were connected, forming a larger island. It is estimated that this larger island was separated from Hokkaido, as well as the Korean Peninsula, even during the Last Glacial Maximum (LGM) (Izuho and Kaifu 2015).

Takahara and Hayashi (2015) reviewed palaeovegetation materials during MIS 3 on the Japanese Islands; they compiled 47 pollen samples from Taiwan, the Japanese Islands, Sakhalin, and the Amur River basin, and reconstructed MIS 3 vegetation in East Asia. Figure 1 displays a topographic and biome-level vegetation map of MIS 3 in East Asia, as presented by Takahara and Hayashi (2015). The topographic map was drawn at 60m below sea level in MIS 3, following Lambeck and Chappell (2001).

The MIS 3 vegetation in the Japanese Islands, reconstructed in Takahara and Hayashi (2015), is summarised as follows. Hokkaido was covered by evergreen conifer forests of spruce, with some larch and broadleaf trees. In northeast Honshu, evergreen conifers such as fir, hemlock, spruce, and pine were dominant, with some deciduous broadleaf trees such as beech, oak and elm. On the Kanto Plain (eastern Honshu), deciduous broadleaf forests of oak, hornbeam, beech, and elm developed. The Pacific coast (Izu Peninsula) was covered by temperate conifers such as Cryptomeria and Sciadopitys, with some deciduous broadleaf trees. The broad part of western Honshu was covered by mixed forests of temperate conifers (such as Cryptomeria, Sciadopitys, and Cupressaceae) and deciduous broadleaf trees (such as beech, oak, hornbeam, and elm). On the northern part of Kyushu, mixed forests of pine and beech were present. After MIS 3, deciduous broadleaf trees (such as beech and oak) and temperate conifers (such as Cryptomeria) were replaced by evergreen conifers (Pinaceae) on Honshu. Overall, the MIS 3 vegetation is characterised by relatively high amounts of deciduous broadleaf trees comprising different types of forests in each region. The distribution patterns of MIS 3 vegetation directly affected the subsequent forests of MIS 2, or the LGM

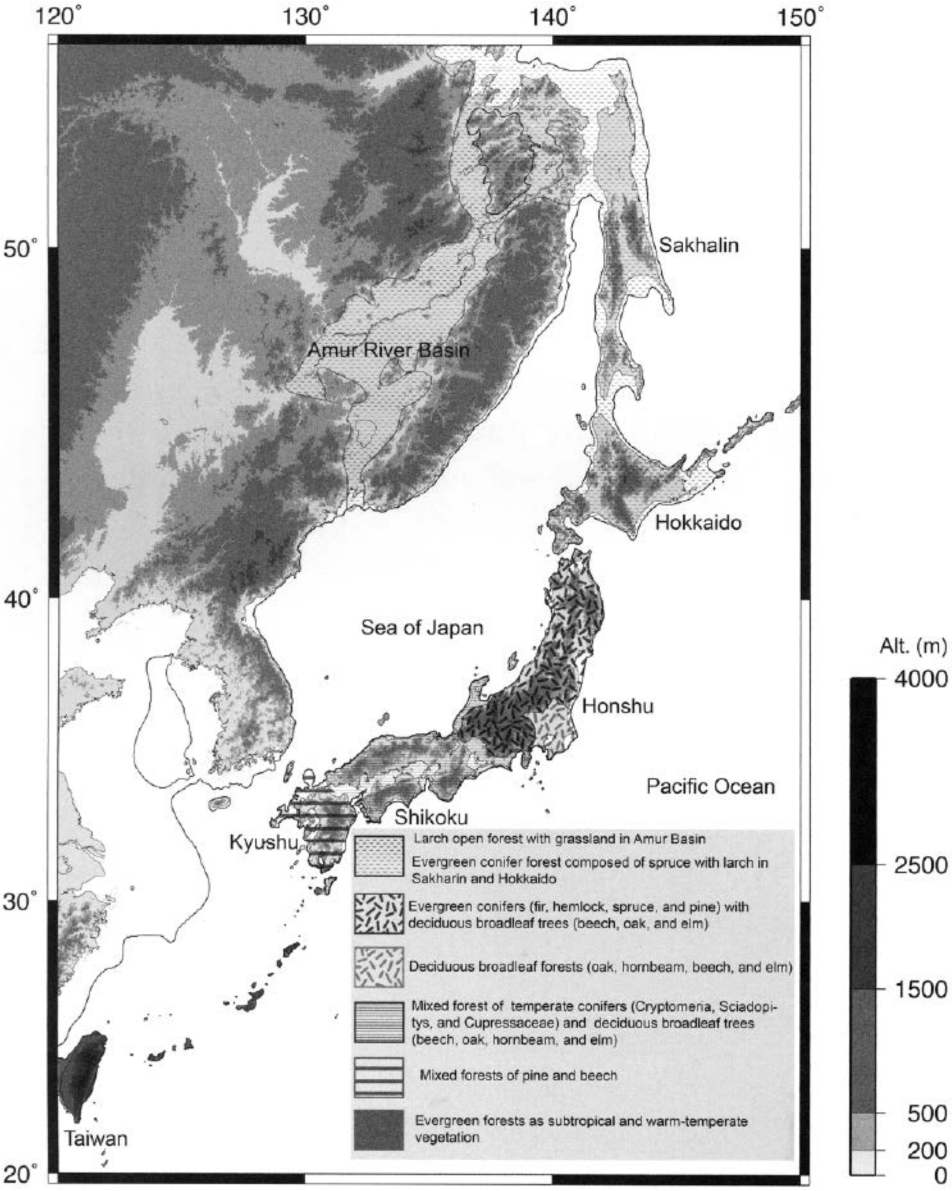

Figure 1 Topographic and biome-level vegetation map of MIS 3 in East Asia (Takahara and Hayashi 2015: Figure 22.2)

(Takahara and Hayashi 2015). Pinaceous conifers (which include both temperate and boreal species) prevailed on the Japanese Islands during the LGM, and temperate broadleaf trees (such as beeches and oaks) and temperate conifers (such as Cryptomeria japonica) existed in coastal refugia (Tsukada 1985).

2) The General Characteristics of Palaeolithic Sites in the Japanese Islands

More than 10,000 Palaeolithic sites have been found on the Japanese Islands, most of them dating back to MIS 2. The dates of the oldest sites accepted by most of researchers date as far back as 38,000 cal BP (Kudo and Kumon 2012; Izuho and Kaifu 2015). Current studies indicate a sudden spike in archaeological sites in the Japanese Islands after 38,000 cal BP. This is seen as a sign of *Homo sapiens*' arrival in the Japanese Islands (Kudo and Kumon 2012; Izuho and Kaifu 2015). The term designating the years from 38,000 to 16,000 cal BP (before the oldest pottery emerged) is called the Upper Palaeolithic (UP) in the Japanese Islands.

Most UP sites in the Japanese Islands are open-air sites. Due to the Islands' humid climate, as well as the nature of deposits which were formed from materials such as volcanic ash and aeolian dust, organic materials at open-air sites dissolve; the only remaining artefacts are made of stone. Aside from excavations of lithic artefacts and cobbles from UP sites, charcoal has also been recovered.

The majority of archaeological excavations at open-air UP sites in the Japanese Islands have been salvage excavations performed to preserve a record of a site before its destruction. Many salvage excavations have been carried out in a wide variety of locations since the high economic growth of the 1970s due to the construction of roads, buildings, and other facilities. The distribution of archaeological features at these sites has therefore been clarified on a large scale; they include lithic, cobble, and charcoal concentrations, and on rare occasions, hearth features. Although a large number of artefacts have been recovered from these excavations, since they must be concluded in a limited time period, dry sieving is employed quite rarely. As a result, the methods used in salvage excavations may to some extent fail to recover smaller items. Under such conditions and methods, large quantities of archaeological material (in particular lithic artefacts) have been accumulated. Furthermore, archaeological materials from the UP sites in several regions are buried in well-stratified, thick aeolian deposits mainly were formed by volcanic ash. Numerous volcanic tephras in and around the Japanese Islands dating from the late Quaternary have been identified and catalogued. In particular, the Aira-Tn tephra (AT), which was ejected from the Aira caldera at 30,009±189 cal BP (Smith et al. 2013; Izuho and Kaifu 2015), is distributed over a broad area, covering most of the Japanese Islands, the Korean Peninsula, part of eastern China, and southern Primorye in the Russian Far East (Machida and Arai 2003); it is used as an indicator to separate the EUP from the Late Upper Palaeolithic (LUP) in the Japanese Islands (Sato 1992). Several other widespread tephras that fell during the Late Pleistocene have been identified, and are used along with local tephras that fell within a smaller zone to conduct chronological research.

3) EUP Research in the Japanese Islands

The dates of EUP assemblages fall roughly between 38,000 cal BP and 29,000 cal BP. About 500 EUP sites have been excavated in the Japanese Islands (Izuho and Kaifu 2015). from the 1970s onwards, cultural chronologies were constructed on the basis of stratigraphy, as well as morphological and technological analyses of stone tools. By the beginning of the 1990s, qualitative morpho-technological analyses of EUP stone tool assemblages were dominant (Sekki Bunka Kenkyu Kai 1991; Sato 1992). They clarified the processes of morphological and technological changes in lithic assemblages during the EUP in the Japanese Islands, and have provided the foundation for current research. Preceding studies also indicat that initial EUP (ca. 38,000–34,000 cal BP) assemblages in the Japanese Islands represent an industry including adzes (with a ground edge) and trapezoids, unique features compared with those in the surrounding parts of East Asia. However, these studies on EUP assemblages have largely progressed based exclusively on the samples from the Japanese Islands, with little attempt at comparisons with EUP evidence from elsewhere. Additionally, these discussions have relied on the assumption of cultural continuity during the UP in the Japanese Islands. Most researchers tend to only examine the production of formal tools in explanations about changes in lithic assemblages. Because of these research biases, morphological and technological changes in EUP lithic assemblages have been mainly explained as the development (i.e., increasing sophistication of tool-making skills) of blade technology and methods of formal tool production.

The author, however, has re-explored EUP assemblages from a different angle, situated in the wider research context of early modern human dispersals and behaviour (e.g., McBreaty and Brooks 2000; Barker et al. 2007; Conard 2008; Habgood and Franklin 2008), and presented another interpretation of changes in EUP assemblages. In past studies, the author showed quantitative data in terms of lithic raw materials selection, core reduction, and formal tool production of EUP assemblages from the Musashino Upland to discuss the transitional processes they imply, and looked at the characteristics of initial EUP assemblages (Yamaoka 2004; 2006; 2011; 2012b). In addition, the author suggested their implications for studies on the behaviour of early modern humans and their dispersal (Yamaoka 2012a; 2014). Based on these studies, hereinafter, the author explains changes in technology and resource use during the EUP on the Japanese Islands.

OBJECTS

1) Study Area and Stratigraphic Sequence

The Musashino Upland is located in the southwestern part of the Kanto Plain in and around Tokyo (Figure 2). The Kanto Plain is the largest plain in the Japanese Islands. In the 1970s, large-scale excavation of Paleolithic sites began in this region prior to those in other pars of the Japanese Islands. To date, more than 200 UP sites have been excavated. Most of these were salvage excavations in response to various industrial developments in and around the city of Tokyo. Among them, more than 60 sites have yielded cultural horizons belonging to the EUP (Hidai 2000). The chronology of the EUP on the Musashino Upland provides a chronological framework for all of the Japanese Islands, as many excavations of UP sites with relatively thick Pleistocene deposits have been conducted there, starting in the earliest stages of research. The Musashino Upland provides rich materials for a re-examination of EUP assemblages.

The Musashino Upland is located downwind of volcanoes that supply volcanic ash. The thick aeolian deposits covering its terraces and other parts of the Kanto Plain are known as ‘Kanto Loam,’ which accumulated starting in the beginning of the Middle Pleistocene. Kanto Loam is a generic name for a series of deposits made up of primary tephra layers, secondary deposits of tephra, aeolian dust (or ‘loess’ from China), fine sand blown from river terraces, and weathered materials. The Kanto Loam is divided into four stratigraphic units whose formation ages roughly correspond to the topographic divisions of the terraces. The Tachikawa Loam is the uppermost deposit among the four divisions, and abundant UP artefacts have been found in this formation.

Studies of the Tachikawa Loam deposits in archaeological contexts started in the 1970s. Researchers have established a total of 12 strata in archaeological contexts (Akazawa et al. 1980) (Figure 3). From Stratum I at the top to Stratum XII at the bottom, these stratigraphic divisions in the Tachikawa Loam are mainly based on differences in soil matrices, including colour, texture, and the inclusion of sediment. Strata I and II are black to dark brown Holocene humus deposits, which have yielded a Holocene archaeological record, while Late Pleistocene archaeological deposits correspond with Strata III to X in the Tachikawa Loam.

Stratum III, the uppermost stratum of the Tachikawa Loam, is a soft, yellowish-brown deposit, in contrast to all the underlying hard deposits. Stratum IV is a brown deposit, while Stratum V is a dark-brown deposit known as the Black Band I (i.e., buried paleosol). The AT tephra is found within the yellowish-brown deposit of Stratum VI. The dark-brown deposits of Strata VII and IX are also known as the Black Band II (i.e., buried palaeosol). Stratum VIII, a yellowish-brown deposit, is sometimes found between Strata VII and IX. The underlying deposits of Stratum IX to the bottom of the Tachikawa Loam are yellowish-brown in colour. Strata X and XII are divided by Stratum XI, which contains large amount of reddish scoria.

As noted above, UP artefacts are found within Strata III to X of the Tachikawa Loam. Lithic assemblages from the lower strata (from Strata VI to X) belong to the EUP. The assemblages from Stratum X are regarded as the initial EUP in this region. Artefacts have never been found from deposits below Stratum XI on the Musashino Upland. The date of assemblages from Stratum VI are expected to be younger than that of the AT tephra, because Stratum VI seems to have begun to accumulate after the fall of the AT tephra. On the other hand, Stratum X is likely to have accumulated after around 40,000 cal BP, based on the age of upper (AT) and lower (SI: 50,000–47,000 BP) key marker tephras, and the assumption that sedimentation rates were constant (Machida 2005).

Accelerator mass spectrometry (AMS) 14C dates were reported from two sites. All of them are based on charcoal. The dates of 29,860 ± 150 BP (Beta-182638) and 30,380 ± 400 BP (Beta-156135) were obtained from hearths in Stratum X at the open-air site of the Musashidai west location (Tokyo Metropolitan Archaeological Center 2004). The date of 26,490±140 (IAAA-70602) is from dense charcoals associated with lithic scatters in Stratum VII; 31,350±210 (IAAA-70603), 30,310±190 (IAAA-70604), 31,200±200 (IAAA-70606), and 30,960±200 (IAAA-70607) are also from dense charcoals associated with lithic scatters in Stratum X at the open-air site of Donoshita (Archaeological Excavation Unit of Suginami Ward 2007; Izuho and Kaifu 2015).

Considering the dates of initial EUP assemblages in other parts of the Japanese Islands, the oldest date of initial EUP assemblages on the Musashino Upland is thought to potentially go back to 38,000 cal BP, although the dates of AMS 14C, which are currently available, are not as old as the assemblages suggest. The date of EUP assemblages in the Musashino Upland is therefore estimated to be around 38,000–29,000 cal BP.

2) Study Assemblages

The study materials that form the basis for this work are from EUP lithic assemblages on the Musashino Upland (Figure 2). The units of analysis are a lithic

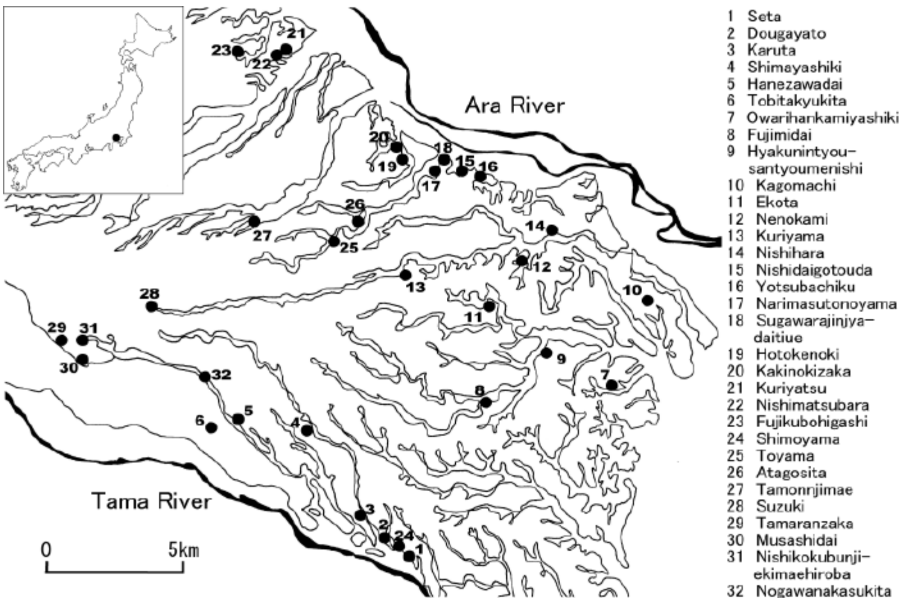

Figure 2 Distribution of the study sites on the Musashino Upland (Yamaoka 2011: Figure 1)

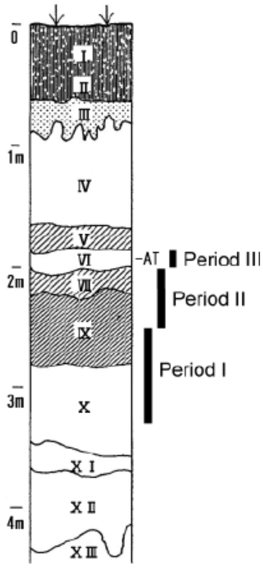

Figure 3 Stratigraphic sequence of Tachikawa Loam (Yamaoka 2011: Figure 2)

artifact scatter or lithic artefact scatters that share lithic artefacts belonging to the same refitted specimen and/or the same lithic raw material unit in an archaeological horizon. A lithic raw material unit is a group of lithic artefacts that are very similar to one another in terms of features such as colour, texture, grain size, and inclusion in the same type of lithic raw material. For research objects, the author only chose sites where stratigraphic layers (to which each lithic artefact scatter belongs) were specified in excavation reports. The author divided EUP lithic assemblages into three sequential periods based on comparisons of lithic assemblage characteristics: lithic raw materials selections, core reductions, and formal tool production (Figure 3). Period I represents lithic assemblages from Stratum X to the lower level of Stratum IX, Period II contains those from the upper level of Stratum IX to Stratum VII, and Period III encompasses those from Stratum VI. A total of 71 analytical units were utilised in the analysis: Period I (n = 18), Period II (n = 31), and Period III (n = 22) (for excavation reports of the sites to which the analytical units belong, see Yamaoka 2011).

RESEARCH METHODS

To illuminate changes in lithic assemblages during the EUP, the author examined three morpho-technological variables in the lithic assemblages: (1) the selection of lithic raw materials, (2) core reduction (mainly for blade technology), and (3) formal tool production, referring primarily to the previous chronological studies (Sekki Bunka Kenkyu Kai ed. 1991; Sato 1992).

(1) The selection of lithic raw materials
The author compared the selection of lithic raw materials among the periods by looking at the amount and weight of obsidian, as well as the other lithic materials such as chert, shale, andesite, tuff, and sandstone. Obsidian is an exotic lithic material on the Musashino Upland, since the closest sources are located more than 80 km away.

(2) Core reduction
The author explored core reduction is examined through the characteristics of the refitted specimens in which blades and elongated flakes are included, as well as the frequency of blade blank tools among flaked tools (formal and informal flaked tools) to evaluate variation in blade reduction during the EUP and the frequency of blade flaking within core reduction methods.

(3) Formal tool production
The author investgated formal tool production by analyzing both formal and informal flaked tool types, as well as adzes with a ground edge. Previously, the author argued that the conventional typology of formal flaked tools in the Japanese EUP was not appropriate due to their vague definitions; therefore the author redefined classes of formal flaked tools using more rigorous criteria (Yamaoka 2006; 2011; 2012b). The author compared the composition of formal and informal flaked tools across the abovementioned three periods. The author quantitatively compared the frequency of formal flaked tools made from obsidian to the frequency of these objects made from other material types. The author also collected information on all specimens of adzes in EUP assemblages on the Musashino Upland (for excavation reports of the sites from which the adzes were recovered, see Yamaoka 2011).

RESULTS OF ANALYSES

1) The Selection of Lithic Raw Materials

Table 1 and Figures 4 and 5 portray the number and the weight of lithic artefacts in each analytical unit of the three periods. The author created Figures 4 and 5 using data from Table 1; the order of analytical units in each period in Figures 4 and 5 is the same as in Table 1. A remarkable increase occurred in the proportion of obsidian use among the assemblages from Periods I to III is observed (as seen in Figure 4), supporting past observations of this trend (Inada 1984; Kanayama 1990; Sekki Bunka Kenkyu Kai 1991). Besides this, Figure 5 indicates another tendency: that the total weight of lithic artefacts in each analytical unit of Phase III is very light, whereas the total weight of lithic artefacts in each analytical unit of in Period I is very heavy. Generally speaking, the weight of lithic artefacts is extremely light in the analytical units where the proportion of obsidian artefacts in the assemblages is high (Figures 4 and 5) because the assemblages include many

Table 1 The number and the weight of lithic artefacts (Modified from Yamaoka 2012b: Table 4)

Period III

Site/Location/Archaeological Holizon	Lithic scatters	All lithic artefacts				Obsidian			
		n	g	g/n		n	%	g	%
Dougayato/-/AH IV	Cluster 1−3	534	1201.7	2.3		511	95.7%	1003.3	83.5%
Suzuki/-/-	Od Grid	456	675.3	1.5		448	98.2%	429.1	63.5%
Yotsubatiku/-/-	Cluster 1−3	452	342.1	0.8		430	95.1%	167.3	48.9%
Yotsubatiku/-/-	Cluster 6−8	128	589.6	4.6		75	58.6%	95.6	16.2%
Yotsubatiku/-/-	Cluster 10	305	98.7	0.3		298	97.7%	93.4	94.6%
Yotsubatiku/-/-	Cluster 20	124	98.1	0.8		122	98.4%	75.5	77.0%
Toyama/Loc. 1/-	Cluster 3,4	180	421.4	2.3		169	93.9%	309.3	73.4%
Toyama/Loc. 1/-	Cluster 5	450	273.6	0.6		449	99.8%	251.7	92.0%
Sugawarajinnjyadaitijyou/-/-	Cluster 4,14,17,24,30	425	2762.6	6.5		0	0.0%	0.0	0.0%
Owarihankamiyashikiato/Loc. 12/-	Cluster 1	185	65.4	0.4		183	98.9%	60.5	92.5%
Owarihankamiyashikiato/Loc. 12/-	Cluster 2	106	20.7	0.2		106	100.0%	20.7	100.0%
Owarihankamiyashikiato/Loc. 12/-	Cluster 3	241	313.5	1.3		241	100.0%	313.5	100.0%
Seta/-/AHVI	Cluster 1−3	214	691.2	3.2		201	93.9%	481.6	69.7%
Shimayashiki-1st excavation/-/-	Cluster DSU2	90	362.6	4.0		83	92.2%	323.3	89.2%
Kuriyama/-./-	Cluster 1,3	79	289.4	3.7		66	83.5%	201.1	69.5%
Tamaranzaka/Loc. 4/AH III	Cluster 4	73	1801.0	24.7		2	2.7%	1.8	0.1%
Fujikubohigashidaisan/Loc. 2/-	Cluster 2	57	155.6	2.7		56	98.2%	140.6	90.4%
Fujikubohigashidaisan	Cluster T2	53	102.2	1.9		42	79.2%	34.3	33.6%
Kuriyatsu/Loc. 15/-	—	49	498.4	10.2		16	32.7%	47.9	9.6%
Hyakunintyousantyoumenishi/-/AH II	Cluster 3	49	724.3	14.8		0	0.0%	0.0	0.0%
Tobitakyukita/-/AH I	—	46	996.0	21.7		0	0.0%	0.0	0.0%
Kuriyatsu/Loc. 16/-	—	41	253.3	6.2		1	2.4%	5.1	2.0%
	Mean	**197**	**578.9**	**5.2**		**159**	**69.1%**	**184.3**	**54.8%**
	Total	**4337**	**12736.7**	**2.9**		**3499**	**80.7%**	**4055.6**	**31.8%**

Period II

Site/Location/Archaeological Holizon	Lithic scatters	All lithic artefacts			Obsidian			
		n	g	g/n	n	%	g	%
Hanezawadai/-/-	Cluster VIIa-VIIbc	1384	32418.2	23.4	233	16.8%	1040.6	3.2%
Narimasutonoyama/-/AH IV	Cluster 1−8	811	5695.0	7.0	82	10.1%	73.4	1.3%
Kagomachi/Koishikawa High School Location./AH I	Cluster 1	493	—	—	493	100.0%	—	—
Kagomachi/Koishikawa High School Location./AH I	Cluster 3	190	—	—	188	98.9%	—	—
Kagomachi/Koishikawa High School Location./AH I	Cluster 5	188	—	—	188	100.0%	—	—
Tamonjimae/-/-	Cluster VIIa- VIIe	289	3509.4	12.1	5	1.7%	4.3	0.1%
Nishidaigotouda/-/AH VII	Cluster 1−7,9	258	2450.5	9.5	1	0.4%	0.3	0.0%
Karuta/-/AH IV	Cluster 1−7	218	—	—	139	63.8%	—	—
Nishikokubunjiekimaehirobatiku-1st excavation/-/AH IV	Cluster 7,8,19,20	213	3611.3	17.0	0	0.0%	0.0	0.0%
Fujimidai/-/AH II	Cluster 1,2	122	3019.5	24.8	1	0.8%	0.2	0.0%
Fujimidai/-/AH II	Cluster 7,8	181	457.2	2.5	118	65.2%	121.7	26.6%
Shimayashiki-2nd excavation/-/AH III	Cluster 3−6	173	2820.8	16.3	0	0.0%	0.0	0.0%
Yotsubatiku/-/-	Cluster 4	126	244.0	1.9	23	18.3%	10.8	4.4%
Yotsubatiku/-/-	Cluster 5	99	802.0	8.1	0	0.0%	0.0	0.0%
Yotsubatiku/-/-	Cluster 13	157	49.3	0.3	157	100.0%	49.3	100.0%
Yotsubatiku/-/-	Cluster 14	104	474.8	4.6	16	15.4%	39.0	8.2%
Dougayato/-/AH V	Cluster 2	110	4527.1	41.2	0	0.0%	0.0	0.0%
Fujikubohigashidaisan	Cluster T-3	88	556.9	6.3	60	68.2%	155.6	27.9%
Atagoshita/-/AH I	—	81	947.9	11.7	26	32.1%	48.3	5.1%
Nishihara/-/AH II	Cluster 2	54	685.2	12.7	2	3.7%	18.1	2.6%
Nishihara/-/AH II	Cluster 3	48	352.7	7.3	0	0.0%	0.0	0.0%
Nishihara/-/AH II	Cluster 4	77	734.7	9.5	0	0.0%	0.0	0.0%
Nenokami/-/-	Cluster 1,2	73	927.8	12.7	0	0.0%	0.0	0.0%
Suzuki/-/-	Nb Grid	69	5219.4	75.6	0	0.0%	0.0	0.0%
Nishimatsubara/Loc. 1/-	—	61	—	—	54	88.5%	—	—
Seta/-/AH VII	Cluster 1	60	240.5	4.0	54	90.0%	198.2	82.4%
Ekota/Loc. B/-	—	59	175.0	3.0	0	0.0%	0.0	0.0%
Hotokenoki	Cluster 2	59	812.5	13.8	1	1.7%	1.3	0.2%
Kakinokizaka/West Location/-	Cluster 5	53	287.5	5.4	0	0.0%	0.0	0.0%
Kakinokizaka/West Location/-	Cluster 16	49	1039.9	21.2	0	0.0%	0.0	0.0%
Fujikubohigashidaisan/Loc. 2/-	Cluster 4	41	37.6	0.9	41	100.0%	37.6	100.0%
	Mean	**193**	**2773.0**	**13.6**	**61**	**31.5%**	**69.2**	**13.9%**
	Total	**5988**	**72096.7**	**12.0**	**1882**	**31.4%**	**1798.7**	**2.5%**

Period I

Site/Location/Archaeological Holizon	Lithic scatters	All lithic artefacts			Obsidian			
		n	g	g/n	n	%	g	%
Musashidai/Loc. A/AH Xa and AH Xb	—	2522	36490.3	14.5	169	6.7%	513.0	1.4%
Tamaranzaka/Loc. 4/AH I	Cluster 1	32	301.8	9.4	0	0.0%	0.0	0.0%
Tamaranzaka/Loc. 8-A/AH I	Cluster 1–4	321	18714.9	58.3	0	0.0%	0.0	0.0%
Tamaranzaka/Loc. 8-A/AH I	Cluster 5–7	56	2877.0	51.4	0	0.0%	0.0	0.0%
Nishidaigotouda/-/AH IXc	Cluster 1	74	169.3	2.3	0	0.0%	0.0	0.0%
Nishidaigotouda/-/AH Xa	Cluster 1,2	123	7668.9	62.3	8	6.5%	43.5	0.6%
Shimoyama-10th excavation/-/AH IV	Cluster 1	162	2485.0	15.3	1	6.2%	1.6	0.1%
Seta/-/AH VIII	Cluster 1–4	420	6102.1	14.5	0	0.0%	0.0	0.0%
Tamonjimae/-/-	Cluster IXa-IXd	73	1450.0	19.9	0	0.0%	0.0	0.0%
Tamonjimae/-/-	Cluster IXh-IXk,IXn	272	2570.9	9.5	34	12.5%	36.1	1.4%
Tamonjimae/-/-	Cluster IXl	73	1829.6	25.1	8	11.0%	0.4	0.0%
Tamonjimae/-/-	Cluseter IXm · IXo	33	761.3	23.1	6	18.2%	—	—
Yotsubatiku/-/-	Cluster 12	231	60.2	0.3	230	99.6%	37.7	62.6%
Suzuki/Miyuki 1stLlocation/AH IV	—	137	2099.0	15.3	0	0.0%	0.0	0.0%
Suzuki/Elementary school underground passage point/AH V	—	44	356.9	8.1	1	2.3%	1.1	0.3%
Nogawanakasukita/East location/AH X	Cluster 1	30	4439.7	148.0	0	0.0%	0.0	0.0%
Nishikokubunjiekimaehirobatiku-1st excavation/-/AH V	Cluster 21–23	90	683.0	7.6	0	0.0%	0.0	0.0%
Fujikubohigashidaini/Loc. B/-	Cluster 4	40	753.4	18.8	0	0.0%	0.0	0.0%
	Mean	**263**	**4989.6**	**28.0**	**25**	**9.1%**	**37.3**	**3.9%**
	Total	**4733**	**89813.3**	**18.8**	**457**	**9.7%**	**633.4**	**0.7%**

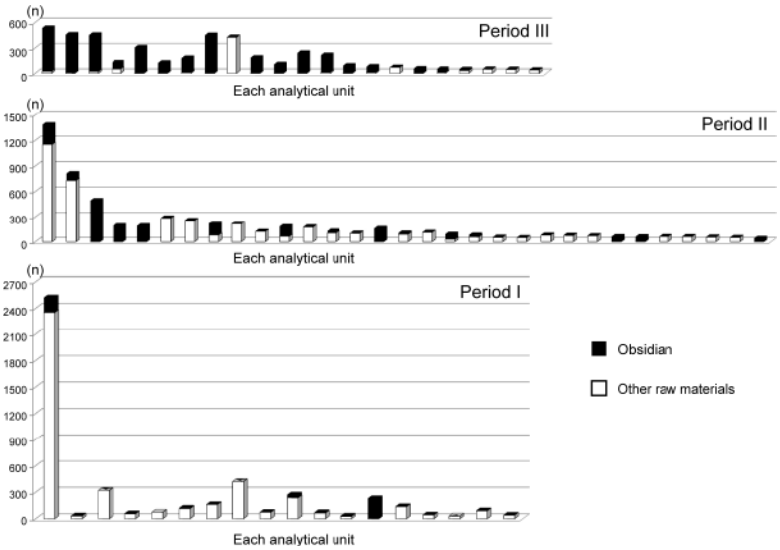

Figure 4 The number of lithic artefacts (Modified from Yamaoka 2012b: Figure 79)

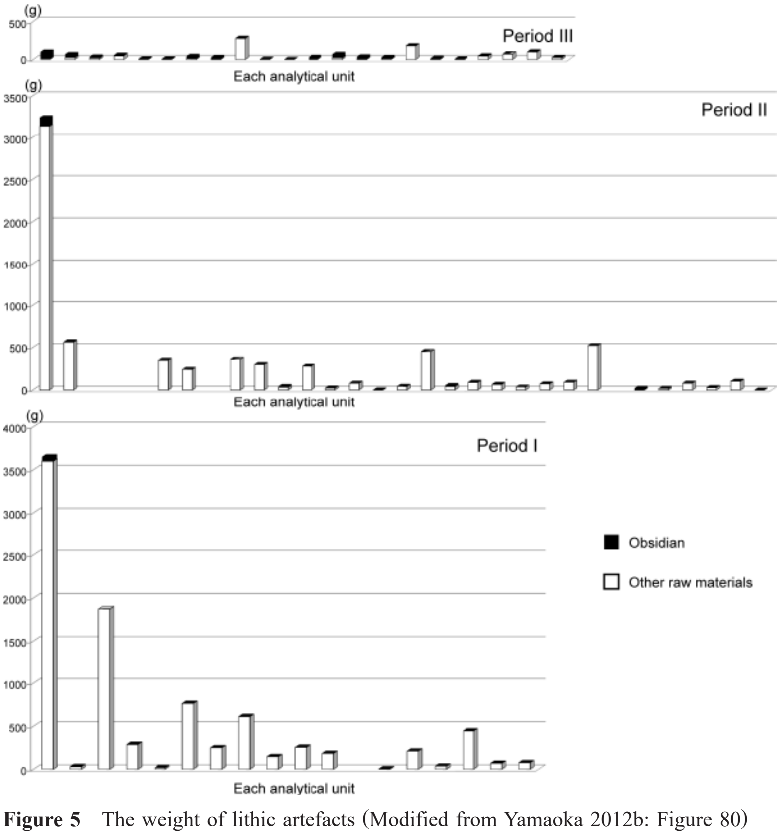

Figure 5 The weight of lithic artefacts (Modified from Yamaoka 2012b: Figure 80)

small obsidian flakes (and chips), while there are few large flakes and cores. Figure 5 also suggests that the total weights of lithic artefacts are extremely heavy for several analytical units in Periods I and II, as those assemblages contain heavy cores or core tools and many large flakes. Most of the non-obsidian lithic raw materials in Period I and II assemblages are locally available low-quality chert from which unmodified amorphous flakes were abundantly manufactured. In contrast, non-obsidian raw materials in Period III assemblages include exotic hard shale and black shale, which are characteristically of high quality. Similar to obsidian artefacts, lithic artefacts made of exotic shale rarely have larger cores and flakes. These observations imply that high-quality materials were frequently chosen for core reduction only during Period III, while other raw materials were mainly selected in Periods I and II.

2) Core Reduction

Figure 6 illustrates refitted specimens resulting from the manufacture of blades and elongated flakes. The refitted specimens including blades are ubiquitously apparent in the Period III assemblages. In most cases of Period III, platform and fringe trimmings are evident; blade cores are included in refitted specimens, and traces of core rejuvenation are sometimes observed. On the other hand, among the assemblages of Periods I and II, few refitted specimens have blades or elongated flakes; platform preparation and core rejuvenation are seldom found, and blade cores are rare.

The author frequently found high-quality raw materials among the refitted specimens including blades and elongated flakes in all periods. In particular, in those of Periods II and III, the majority of the refitted specimens are obsidian, while the size of refitted specimens became larger in Period III. Thus, during Period III blade technology came to be more dominant, coupled with the increased use of high-quality and large materials.

Figure 7 displays the percentages of blade blank tools made out of blades among flaked tools (formal and informal flaked tools) in analytical units, as well as their mean and total in each period. A remarkable increase in the use of blade blank tools from Periods I to III can be seen, suggesting that blade technology came to be a principal method of core reduction in Period III. These findings support previous observations of the manifestation of blade technology in the final EUP (Kakubari and Fujinami 1986, 1987; Sekki Bunka Kenkyu Kai 1991).

3) Formal Tool Production

Figure 8 outlines the definitions of formal flaked tool types in this study, while Table 2 lists the number of ‘Flaked tools and flakes (longer than 2 cm)’, ‘Formal flaked tools (types A–H)’, and ‘Informal flaked tools (marginally retouched flakes, except for types A–H)’. The number of ‘Flaked tools and flakes (longer than 2 cm)’ indicates the total number of formal flaked tools, informal flaked tools, and flakes longer than 2 cm. The numbers in parentheses in Table 2 designate the

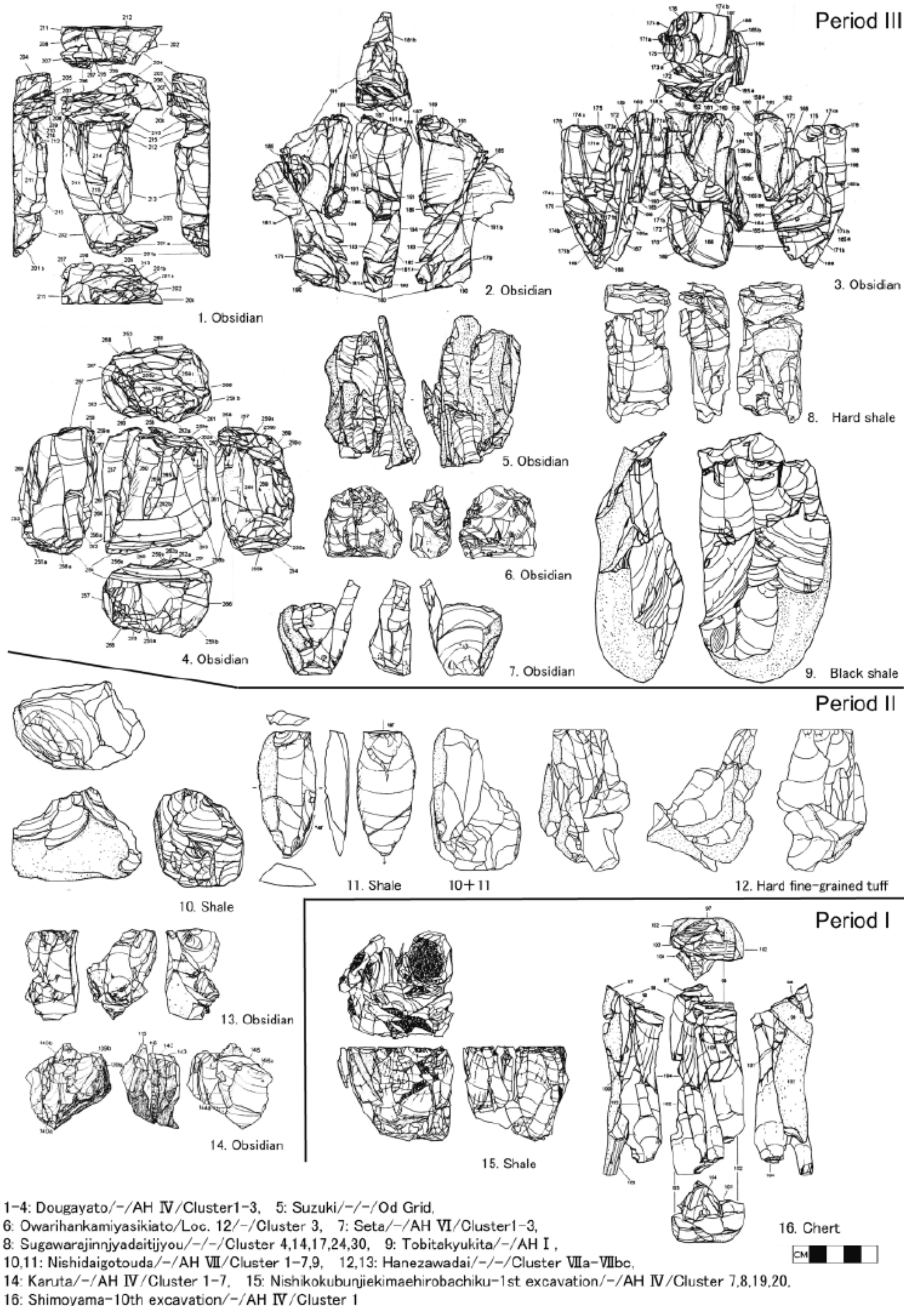

Figure 6 Refitted specimens (Yamaoka 2011: Figure 3)

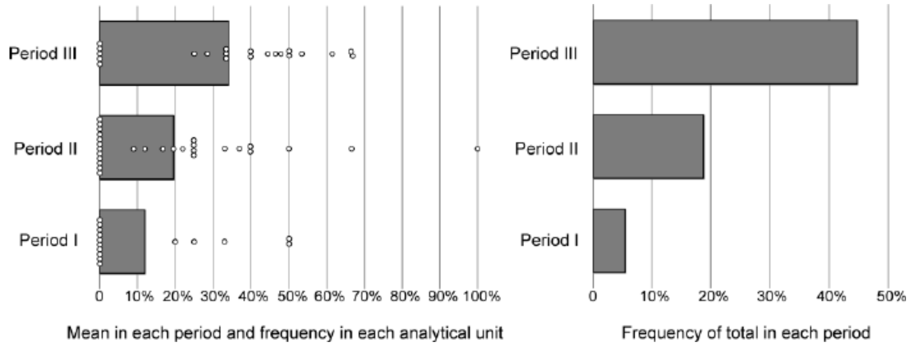

Figure 7 The frequency of blade blank tools in formal and informal flaked tools (Modified from Yamaoka 2012b: Figure 87)

numbers of obsidian specimens. These data indicate that the composition of classes of formal flaked tools (i.e., types A–H) changed during the EUP. Amounts of types A–F varied over time, while types G (side scraper) and H (end scraper) are, by and large, evenly distributed in the assemblages of all periods. In Period I, types A (pointed flake), D, E (trapezoid), and F (pen-head shaped point) are notable. On the other hand, in the assemblages of Period III, types A, B, and C (pointed blades and flakes) exist in significant quantities. The composition of formal flaked tools in Period II has an intermediate characteristic between Periods I and III.

Using the data from Table 2, the author created Figure 9 to exhibit the frequencies of formal flaked tools among (formal and informal) flaked tools, and flakes that are longer than 2 cm in all analytical units, as well as their mean and total in each period. The author set a standard of 'longer than 2 cm' for size as a condition to control the comparison of the frequencies between analytical units. Frequencies of obsidian formal flaked tools are generally high in the assemblages of all periods. However, taking 'all' lithic raw materials into account, the analysis confirmed an overall increase in the frequencies of formal flaked tools from Periods I to III. Percentages of formal flaked tools in the 'Other' category of raw materials also increased from Periods I to III. This trend accords with a rise in the

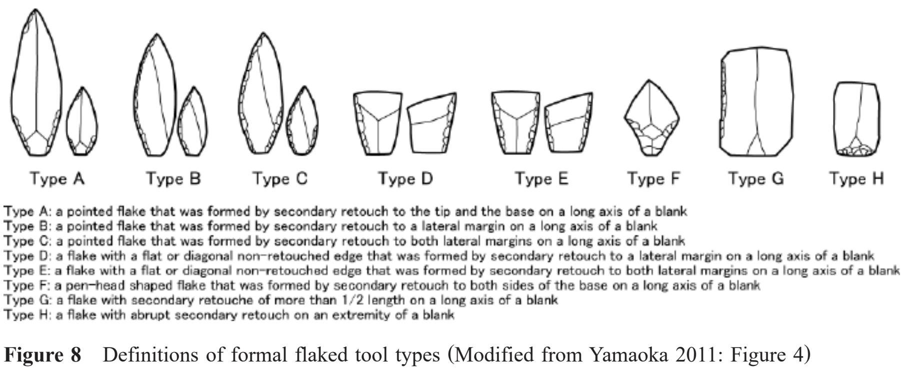

Figure 8 Definitions of formal flaked tool types (Modified from Yamaoka 2011: Figure 4)

Table 2 Flaked tools (Yamaoka 2011: Table 4)

Period III

Site/Location/ Archaeological Holizon	Lithic scatter	Flaked tool and flake (longer than 2 cm)	Formal flaked tool								Informal flaked tool
			TypeA	TypeB	TypeC	TypeD	TypeE	TypeF	TypeG	TypeH	
Dougayato/-/AH IV	Cluster 1–3	172 (166)	2 (1)	2 (2)	8 (8)				1		13 (13)
Suzuki/-/-	Od Grid	90 (82)	1 (1)	4 (4)	7 (7)	2 (2)					14 (11)
Yotsubatiku/-/-	Cluster 1–3	54 (42)		1 (1)	1 (1)						2 (2)
Yotsubatiku/-/-	Cluster 6–8	54 (16)	1	1	1 (1)				2 (1)		3
Yotsubatiku/-/-	Cluster 10	24 (23)	1 (1)	1 (1)	1 (1)						2 (2)
Yotsubatiku/-/-	Cluster 20	27 (27)		1 (1)	2 (2)						
Toyama/Loc. 1/-	Cluster 3,4	91 (80)	1	2 (2)	7 (7)				5 (5)		10 (10)
Toyama/Loc. 1/-	Cluster 5	77 (76)		1 (1)	2 (2)				3 (3)	2 (2)	3 (3)
Sugawarajinnjyadaitijyou/-/-	Cluster 4,14,17,24,30	237 (0)		5	8					1	12
Owarihankamiyashikiato/Loc. 12/-	Cluster 1	30 (29)							1 (1)		5 (4)
Owarihankamiyashikiato/Loc. 12/-	Cluster 2	5 (5)									1 (1)
Owarihankamiyashikiato/Loc. 12/-	Cluster 3	63 (63)		3 (3)						1 (1)	5 (5)
Seta/-/AHVI	Cluster 1–3	110 (101)	1 (1)	6 (6)	2 (2)						4 (3)
Shimayashiki-1st excavation/-/-	Cluster DSU2	36 (31)	1 (1)						2 (2)		2 (2)
Kuriyama/-./-	Cluster 1,3	38 (32)	1 (1)	1 (1)	2 (2)				1 (1)		7 (6)
Tamaranzaka/Loc. 4/AH III	Cluster 4	58 (0)									
Fujikubohigashidaisan/Loc. 2/-	Cluster 2	25 (24)		1 (1)					1 (1)		1 (1)
Fujikubohigashidaisan	Cluster T2	8 (7)					1 (1)			3 (2)	
Kuriyatsu/Loc. 15/-	—	44 (13)			1				2		2 (1)
Hyakunintyousantyoumenishi/-/AH II	Cluster 3	21 (0)		2							2
Tobitakyukita/-/AH I	—	36 (0)	2								1
Kuriyatsu/Loc. 16/-	—	33 (1)									1

Obsidian in parentheses

Period II

Site/Location/ Archaeological Holizon	Lithic scatter	Flaked tool and flake (longer than 2 cm)	Formal flaked tool								Informal flaked tool
			TypeA	TypeB	TypeC	TypeD	TypeE	TypeF	TypeG	TypeH	
Hanezawadai/-/-	Cluster VIIa-VIIbc	1009 (153)	5 (3)	7 (6)	6 (1)	2 (2)	1		9 (1)		48 (25)
Narimasutonoyama/-/AH IV	Cluster 1–8	255 (19)		1	2 (1)		1		3		15 (2)
Kagomachi/Koishikawa High School Location./AH I	Cluster 1	118 (118)		4 (4)	3 (3)	1 (1)			1 (1)	1 (1)	10 (10)
Kagomachi/Koishikawa High School Location./AH I	Cluster 3	62 (61)	1 (1)		1 (1)		1 (1)				2 (2)
Kagomachi/Koishikawa High School Location./AH I	Cluster 5	34 (34)	2 (2)		1 (1)				1 (1)		5 (5)
Tamonjimae/-/-	Cluster VIIa- VIIe	196 (0)							4	1	5
Nishidaigotouda/-/AH VII	Cluster 1–7,9	154 (0)			1	1	2		6	2	13
Nishikokubunjiekimaehirobatiku-1st excavation/-/AH IV	Cluster 7,8,19,20	149 (0)			4				1	1	2
Fujimidai/-/AH II	Cluster 1,2	54 (0)							2		6
Fujimidai/-/AH II	Cluster 7,8	43 (18)		3 (3)		1 (1)			1 (1)		3 (3)
Shimayashiki-2nd excavation/-/AH III	Cluster 3–6	116 (0)				1					1
Yotsubatiku/-/-	Cluster 4	20 (3)									1
Yotsubatiku/-/-	Cluster 5	38 (0)		1	1						3
Yotsubatiku/-/-	Cluster 13	13 (13)			2 (2)	1 (1)					
Yotsubatiku/-/-	Cluster 14	41 (7)	1 (1)		1 (1)						4
Dougayato/-/AH V	Cluster 2	71 (0)				1					1
Fujikubohigashidaisan	Cluster T-3	42 (28)	2 (2)	1 (1)	2 (2)						5 (3)
Atagoshita/-/AH I	—	54 (7)	1 (1)		2 (1)					1 (1)	
Nishihara/-/AH II	Cluster 2	35 (2)		1 (1)							2 (1)
Nishihara/-/AH II	Cluster 3	40 (0)									
Nishihara/-/AH II	Cluster 4	35 (0)									
Nenokami/-/-	Cluster 1,2	19 (0)			1						2
Suzuki/-/-	Nb Grid	50 (0)							1		1
Nishimatsubara/Loc. 1/-	—	35 (31)		1 (1)	2 (2)						1 (1)
Seta/-/AH VII	Cluster 1	34 (30)		1		1 (1)					4 (4)
Ekota/Loc. B/-	—	29 (0)							1		
Hotokenoki	Cluster 2	40 (1)			1						3
Kakinokizaka/West Location/-	Cluster 5	30 (0)			2						2
Kakinokizaka/West Location/-	Cluster 16	26 (0)			2						2
Fujikubohigashidaisan/Loc. 2/-	Cluster 4	10 (10)									

Obsidian in parentheses

Period I

Site/Location/ Archaeological Holizon	Lithic scatter	Flaked tool and flake (longer than 2 cm)	Formal flaked tool								Informal flaked tool
			TypeA	TypeB	TypeC	TypeD	TypeE	TypeF	TypeG	TypeH	
Musashidai/Loc. A/AH Xa and AH Xb	—	1380 (76)	1			1 (1)	1 (1)		7 (3)	5 (1)	34 (6)
Tamaranzaka/Loc. 4/AH I	Cluster 1	21									1
Tamaranzaka/Loc. 8-A/AH I	Cluster 1–4	246				1	1		1	2	5
Tamaranzaka/Loc. 8-A/AH I	Cluster 5–7	42	2						1		2
Nishidaigotouda/-/AH IXc	Cluster 1	20									
Nishidaigotouda/-/AH Xa	Cluster 1,2	49 (5)							1 (1)		3 (3)
Shimoyama-10th excavation/-/AH IV	Cluster 1	128 (1)			1						1
Seta/-/AH VIII	Cluster 1–4	253				1				1	2
Tamonjimae/-/-	Cluster IXa-IXd	60					1				2
Tamonjimae/-/-	Cluster IXh-IXk,IXn	180 (7)				1		1 (1)	5 (4)		5 (2)
Tamonjimae/-/-	Cluster IXl	51					1		2		1
Tamonjimae/-/-	Cluseter IXm · IXo	23									
Yotsubatiku/-/-	Cluster 12	15 (14)	1		2 (2)						
Suzuki/Miyuki 1stLlocation/AH IV	—	63							1		2
Suzuki/Elementary school underground passage point/AH V	—	35	1			1		1			1
Nogawanakasukita/East location/AH X	Cluster 1	21							1		1
Nishikokubunjiekimaehirobatiku-1st excavation/-/AH V	Cluster 21–23	76									
Fujikubohigashidaini/Loc. B/-	Cluster 4	27	3								1

Obsidian in parentheses

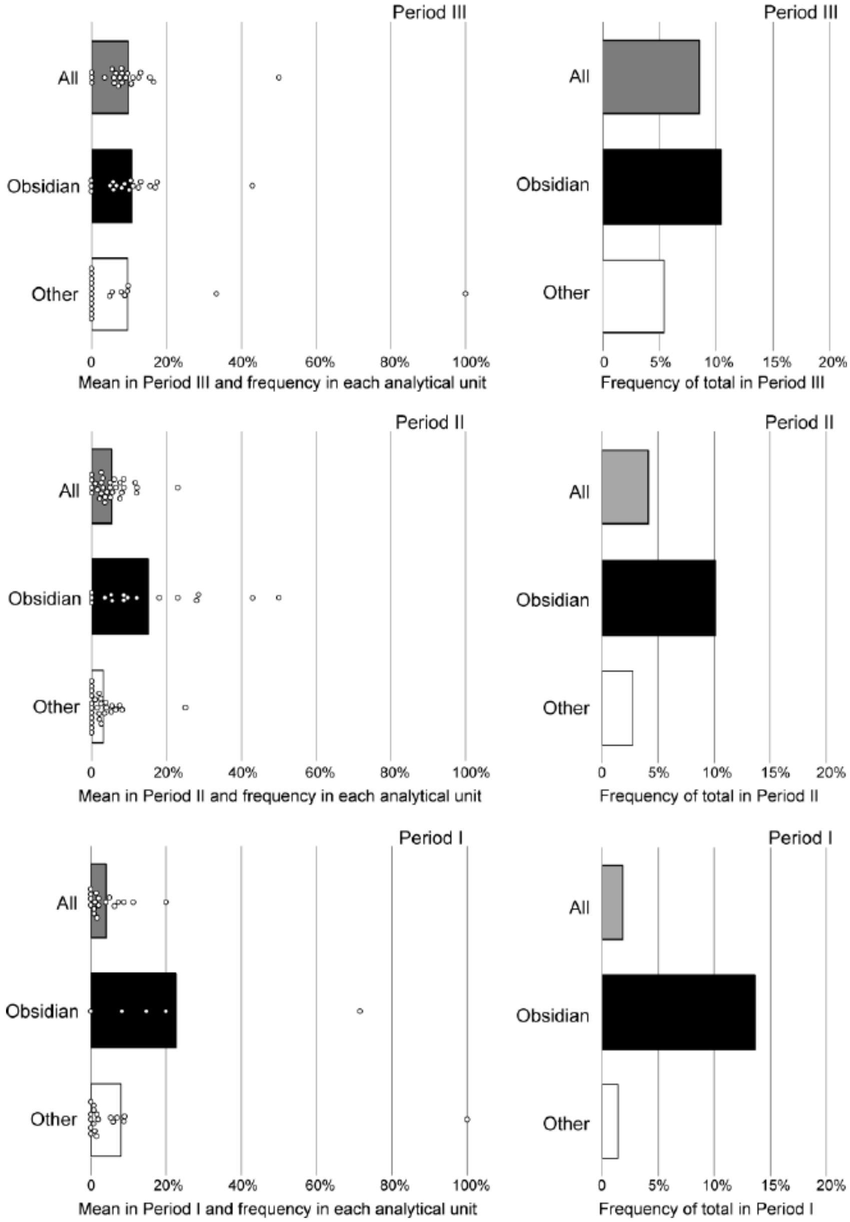

Figure 9 The frequency of formal flaked tools (Modified from Yamaoka 2012b: Figure 88)

share of obsidian artefacts and other artefacts of high-quality material from Periods I to III. This suggests an expansion of formal flaked tool production, as well as the expanded use of high-quality materials (both obsidian and other classes of materials) in Period III.

Adzes are either unifacially or bifacially shaped core tools with a convex cross-

Table 3 Adzes (Yamaoka 2011: Table 6)

Site/Location/Archaeological Holizon	Geological Horizon	From lithic scatters	From outside of lithic scatters	Detail excavated position uncertain
Shimayashiki-2nd excavation/-/-	VII		1	
Fujimidai/-/-	IX upper	1		
Shimozatohonnmura/-/-	IX middle	1		
Tamonjimae/-/-	IX lower	2		
Hakeue/-/-	IX lower		2	
Higashihayabuchi/-/-	IX lower	5		
Higashihayabuchi/-/-	X	1		
Higashihayabuchi/Loc. 4/AH II	IX lower - X		1	
Tamaranzaka/-/-	X	1		
Tamaranzaka/Loc. 5/AH I	Xa - Xc	6		
Tamaranzaka/Loc. 5/AH II	IX lower - Xa		1	
Tamaranzaka/Loc. 8-A/AH I	IXb - Xc	5		
Musashidai/Loc. A/AHXa and AH Xb	Xa / Xb	8		
Musashidai/West Location/AH I	Xb	4		
Hanazawahigashi/-/-	X		1	
Shimoyama-2nd excavation/-/-	X		1	
Seta/-/AH VIII	X	2	1	
Kurihara/-/-	X	1		
Momijiyama/-/-	X	2		
Fujikubohigashidaini/Loc. B/-	X	1		
Nogawanakasukita/East location/AH X	X	1		
Nishidaigotouda/-/AH IXb	Xb	1		
Ozaki	(X)	1		
SuzukiII/-/-	(X)			1
Suzuki III/Loc. B/-	(IX lower)			5
Suzuki III/Loc. D/-	(IX lower)			6
SuzukiIV/-/-	(IX)			3
Suzuki/Housing and Urban Development Corp. site/-	X	1		
Takaidohigashi	(IX middle)			2
Takaidohigashi	(X)			2
Takaidohigashi/The parking lot West Location/-	(X)		1	

section, and sometimes a ground edge. Table 3 shows the number of all specimens of adzes from EUP assemblages on the Musashino Upland. The gray background in Table 3 represents the sites that contain the analytical units of the abovementioned examinations. Adzes are quite evident in Stratum X to lower Stratum IX, but seldom found in levels above lower Stratum IX. The frequency of occurrence of adzes roughly coincides with the change in formal flaked tool composition from Periods I to II. Palaeolithic archaeologists have recognized the early occurrence of adzes (mostly derived from the vicinity of the bottom of the Tachikawa Loam) since the beginning of EUP research in the 1970s (Toda and

Archaeological Excavation Unit for the Suzuki site 1976). The present data on these newly discovered specimens further support this observation. The lithic raw materials preferentially used for adzes are tuff and sandstone, which are distinct from those used for formal flaked tools.

DISCUSSION AND CONCLUSION

1) Summary of Results

The lithic data presented in this study exhibit two remarkable characteristics in all periods: (1) high-quality lithic raw materials were especially used for the refitted specimens on which blades and elongated flakes were manufactured; and (2) formal flaked tools were frequently made from high-quality lithic materials (e.g., obsidian and hard shale). These observations imply that high-quality materials were preferentially selected for both blade flaking and the manufacture of formal flaked tools, presumably because high-quality materials have good flaking properties that ensure a reduced failure rate when producing blades and elongated flake blanks, and are more easily retouched. It is therefore legitimately hypothesised that hunter-gatherers would have favoured high-quality materials to produce blades and make formal flaked tools. To further inspect the lithic assemblages, the author attempted to delineate diachronic trends of change in the selection of lithic raw materials, core reduction (mainly for blade technology), and formal tool production during the EUP on the Musashino Upland.

Period I: In Period I, the frequency of obsidian use and of formal flaked tool production are both quite low; most unmodified flakes and cores were made from locally available, low-quality chert. This may indicate that the initial EUP hunter-gatherers did not prefer high-quality lithic raw materials in the earliest period. Although elongated flakes and formal flaked tools are present, they emerge only sporadically in assemblages. The mean weights of lithic artefacts in the assemblages are heavier than those of later periods. These patterns suggest that unmodified flakes and core tools containing adzes were the dominant lithic tools in this period. Groups of hunter-gatherers on the Musashino Upland during Period I preferentially employed generalised core reduction using locally available materials.

Period II: The proportion of obsidian in Period II is higher than in Period I; high-quality lithic raw materials were more frequently utilised. Formal flaked tools and blade blank tools are more commonly found in the assemblages of Period II than of Period I, while there are as few refitted specimens including blades or elongated flakes as in Period I. Because of these characteristics, Period II is regarded as a time of transition between Periods I and III.

Period III: In Period III, the frequency of obsidian use is the highest of all the periods, and most of the lithic raw materials are of high quality (e.g., hard shale). These patterns indicate that high-quality lithic raw materials were commonly chosen in Period III assemblages. The refitted specimens including blades are ubiquitously found in the assemblages; blade blanks are also more often found among flaked tools. In addition, the frequency of formal flaked tools is high. These features of the assemblages (the frequent use of high-quality materials, blades, and formal flaked tools) imply that the production and use of blades and formal flaked tools came to be more critical for hunter-gatherers' way of life during Period III compared to previous periods.

2) Interpretations of Changes in Lithic Assemblages during the EUP on the Musashino Upland

The changes observed in the relationships between tool blank production and raw material usage from Periods I to III are not interpreted as a simple scheme of technological development (i.e., increased sophistication and the proliferation of blade technology and methods of formal tool production), but likely reflect drastic shifts in the purpose and manner of lithic raw materials use since lithic raw materials selection, core reduction, and formal tool production all changed simultaneously. The exclusive use of high-quality materials for making blades (or elongated flakes) and formal flaked tools is consistently found in the EUP, suggesting that high-quality materials were chosen to carry out similar tasks. Nevertheless, the assemblages of Period I exhibit unusual characteristics, with abundant use of unmodified, amorphous flakes and core tools made from local materials. The unmodified, amorphous flakes are believed to have been used expediently. These aspects of Period I assemblages contrast with the general characteristics of UP assemblages.

The environmental transformations (explained in the introduction) are roughly consistent with the transition of lithic assemblages from Periods I to III. Hence, the changes in the lithic raw materials usage are thought to reflect changes in the adaptational behaviour of hunter-gatherers in those time periods, in response to the environmental changes.

The shifts in lithic raw materials use could have been related to alterations in technologies associated with organic raw materials (not archaeologically visible but presumably existing), possibly in response to changes in the environmental setting (Yamaoka 2004). As opposed to the abundant occurrence of formal flaked tools and blade technology during Period III, which are ubiquitously found among Japanese LUP assemblages, unmodified flakes and core tools containing adzes are dominant in Period I assemblages. As noted before, these initial EUP assemblages are seen as unusual in comparison to lithic assemblages from the same period in other regions. However, the tool assemblages of Period I appear somewhat similar to Pleistocene lithic assemblages in Southeast Asia, where it is thought that informal lithic tools were frequently utilised to produce perishable tools (Hutterer 1976). Use-wear analysis of adzes in the Japanese EUP shows that they functioned to perform multiple tasks, including hide-scraping and wood-cutting (Tsutsumi 2006). In addition, evidence of breakage patterns implies that large adzes could have been used for heavy-duty tasks (Sato 2006). Thus, it is believed that the most probable use of larger adzes was for clearing the forest and woodworking (Tsutsumi 2006). Some researchers have pointed that the hunter-gatherers of the initial EUP in the Japanese Islands were more dependent on plant resources for making tools and instruments than those of the UP in northern Eurasia and Europe, who are responsible for the blade/microblade assemblages found there (Sato 2006; Inada 2007).

Palaeoenvironmental data seem to support the possibility of significant changes in organic raw materials usage during the EUP in this region. The pollen data (Takahara and Hayashi 2015) indicate the vegetational transformation from MIS 3 to MIS 2 in the Japanese Islands, as mentioned above. In the Kanto Plain where the Musashino Upland is located, analysis of pollen spectra and evidence of plant fossils also point to the occurrence of a vegetational shift from broadleaf deciduous to coniferous forests after the AT tephra fell (Tsuji and Kosugi 1991; Ito 1992). This shift in forest types roughly corresponds to the transition from Periods I to III. In addition, opal phytolith analysis revealed the expansion of grassland vegetation from the initial to the later periods of the EUP (Sase et al. 2008). This transformation roughly correlates with decreasing quantities of adzes within assemblages. Thus, groups of hunter-gatherers during Period I are thought to have been heavily dependent on plant resources for their entire technological system (Yamaoka 2011; 2012b).

The modification in lithic materials use could be also explained by changes in the scale of foraging territory and residential mobility, along with climatic (specifically climate cooling) and vegetational changes. Many studies suggested that human foraging territory expanded during the final EUP, based on the presence of relatively large amounts of obsidian from Shinshu, a few hundred kilometres away from the Musashino Upland (e.g., Inada 1984; Kanayama 1990; Sekki Bunka Kenkyu Kai 1991; Tamura 1992). In past Japanese UP research, there were two initial hypotheses concerning lithic raw materials procurement strategies: one based on direct procurement (Ono 1975), and one grounded in exchanges (Harunari 1976). Recently, most researchers seem to have discussed raw material procurement from the assumption of an ‘embedded strategy’ (Binford 1979). However, there are no data on specific foraging routes between obsidian provenance areas and sites on the Musashino Upland, and there is no direct evidence of how lithic raw materials were procured. Therefore, the author stresses the possibility of differences in the scale of foraging territoriy, with smaller areas during Period I than later periods of the EUP in colder environments (Yamaoka 2004; 2006; 2011; 2012b).

Moreover, the increasing reliance on obsidian for formal flaked tools from Periods I to III was clearly demonstrated in this research. Given the frequent use of blade technology and lighter formal flaked tools in Period III assemblages, it is possible that the residential mobility of foraging groups increased during this time (Andrefsky 2005). On the other hand, the residential mobility of foraging groups during Period I is thought to have been relatively low due to infrequent use of lighter formal flaked tools, coupled with heavier mean weights of lithic artefacts.

3) The Implications of Changes in Lithic Assemblages during the EUP on the Japanese Islands

Based on previous studies focusing on the Japanese Islands (Sekki Bunka Kenkyu Kai 1991; Sato 1992), it is thought that the change in lithic raw materials usage (which is explained in this paper based on data from the Musashino Upland) took place across a large area of the Japanese Islands during the EUP. Trapezoids and adzes are included in initial EUP assemblages in many parts of the Japanese Islands. Blade technology and formal flaked tools are dominant in final EUP assemblages; regional variability of lithic assemblages in the Japanese Islands becomes to be more clearly defined after the final EUP. These shifts in entire EUP lithic assemblages in the Japanese Islands are also thought to reflect modifications of technological adaptations related to alterations in overall technological systems encompassing organic raw materials use, and also involving transformations in the scale of foraging territory, as well as residential mobility within specific environmental settings, based on this research and other palaeoenvironmental data (Takahara and Hayashi 2015).

Thus far, archaeologists have found different kinds of adaptive behaviour in different environmental settings, and have discussed the flexibility of early modern humans' techno-adaptive strategies (Barker et al. 2007; O'Connor et al. 2011; Hiscock 2015; Roberts and Amano 2019). In the Japanese Islands, early modern humans adopted different kinds of techno-adaptive strategies in response to changing environmental settings. In addition, evidence shows the flexible adaptational abilities of hunter-gatherers during this time period.

Such substantial changes in technological adaptation may be due to two aspects of the geographic position of the Japanese Islands. They are situated in the middle latitudes; the climate could become either cold or warm. The environment in the colder period was relatively similar to that of high latitudes, while the environment in the warmer period was relatively similar to that of low latitudes. Initial EUP assemblages left by hunter-gatherers in the warmer period are roughly similar to amorphous flake tool and core tool assemblages in Southeast Asia. On the other hand, final EUP assemblages left during the colder period are roughly similar to blade assemblages in northern Eurasia. To understand the changes in Japanese EUP assemblages, it is important to consider not only the relationships between environmental settings, climate change, and the geographic position of the Japanese Islands, but also the relationship between the process of modern human dispersal and the geographic position of the Japanese Islands.

The Japanese Islands are located at a considerable distance from Africa, where modern humans emerged. Goebel (2007) explored the dispersal of early modern humans based on fossil, archaeological, and DNA evidence, explaining that early modern human dispersal took place along two routes in different periods. The earlier spread of early modern humans was from an East African source from

60,000 to 40,000 years ago. The eastward migration likely proceeded along the South Asian coast to insular Southeast Asia, and ultimately to Australia by 50,000 to 45,000 years ago. On the other hand, the later spread of early modern humans was from a West Asian source to the Mediterranean, temperate Europe, Russia, and Central Asia from 45,000 to 35,000 years ago. They reached southern Siberia by 45,000 years ago, and arctic Siberia by 30,000 years ago. Based on this explanation, the Japanese Islands are situated in the middle of both routes, and could have been reached by early modern humans from both routes.

Kaifu *et al*. (2015) compiled palaeo-anthropological and archaeological data related to the dispersal of early modern humans in east Eurasia. They suggested that the new data set supports simultaneous, explosive patterns of the initial dispersal of modern humans across almost all of Eurasia after 50,000 years ago. However, Clarkson *et al*. (2017) suggested that human occupation began around 65,000 years ago in northern Australia. Bae *et al*. (2017) estimated that the initial dispersal of modern humans across Asia goes back to before 60,000 years ago, mainly based on fossil and archaeological evidence. Discussions of the dispersal dates of early modern humans in the east Eurasia seem set to continue; however, the technological features of lithic assemblages from the initial phase of the Japanese EUP are similar to those of Pleistocene lithic assemblages in Southeast Asia and Australia on the southern route, while technological features of lithic assemblages from later phases (especially the final phase) of the Japanese EUP are similar to those of EUP lithic assemblages in Northern Asia on the northern route (Yamaoka 2014).

Late Pleistocene lithic assemblages in regions such as Southeast Asia and Australia are mainly composed of amorphous flakes and core tools; they also contain axes or adzes. Core-axes/adzes have been found in Late Pleistocene Hoabinhian lithic assemblages from Vietnam (Nguyen 2005; Yi et al. 2008; Nguyen 2015) and southern China (Ji et al. 2016), with the oldest dating to 43,500 years ago (Ji et al. 2016). Edge-ground and/or waisted adzes/hatchets are contained in late Pleistocene lithic assemblages in Australia and New Guinea (Habgood and Franklin 2008), with the oldest dating back to 65,000 years ago (Clarkson et al. 2017).

On the other hand, lithic assemblages of the EUP in northern Asia have blade-based lithic technologies with sophisticated blade flaking technology. Recently, dating of the appearance of blade technology from East Asia regions has been clarified; the reason it emerged has been argued for each region. The Levallois and prismatic blade methods combined to form the characteristics of the early stages of the UP in China. Artefacts bearing such characteristics were distributed in northern China some 30,000 to 40,000 years ago (Li et al. 2016). Based on similarities in technological organisation and geographic connections with those discovered in Siberia and Mongolia, their emergence is interpreted as a reflection of population migration (Li et al. 2016). Reliable dates for blades and the tanged point industry in the Korean peninsula are set at around 36,000 years ago (Seong 2011). Some researchers think of this emergence and establishment as resulting from direct occasional migration from northern regions, or some type of trade interaction (Bae 2010; Bae and Bae 2012). On the other hand, many Japanese researchers have concluded that the blade technology was independently developed in the Japanese Islands (e.g., Anzai 2003; Suto 2017), although some researchers explain the appearance of (and changes in) blade technology via technological diffusion or population migration (Inada 2001; Takeoka 2011). Recently, Morisaki *et al*. (2019) evaluated AMS radiocarbon dates from Japanese EUP assemblages and roughly compared Japanese EUP blade technology with blade technology from the Initial Upper Palaeolithic (IUP) industry of western Eurasia, IUP-like assemblages in China, and EUP assemblages in Korea. Using this comparison, they estimated multiple technological diffusions or population migrations among the Japanese Islands and the Korean Peninsula, while direct influence from China or western Eurasia was improbable (Morisaki et al. 2019). Discussions concerning the reasons for the appearance of blade technology in the Japanese Islands seem set to continue for the time being.

Pleistocene lithic assemblages from Australia contain important comparative data in terms of the meaning of the changes in technological adaptation and the appearance of sophisticated blade technology in the Japanese EUP. Amorphous flake assemblages with little blade technology continued during the Pleistocene in Australia (Habgood and Franklin 2008), despite various environmental settings and large climatic shifts during this time (Davidson 2010). This indicates that modern humans could not necessarily or consistently invent the technological systems, including blade technology, according to environmental conditions. Like the Japanese Islands, Australia is situated a considerable distance from Africa, but it is located in the southern hemisphere, farthest away from the northern route. This signals that the changes in technological adaptation identified during the Japanese EUP may not have arisen only from hunter-gatherers' technological flexibility alone, but instead that their technological system (including blade technology) could have been transmitted (or brought) by another human group to the Japanese Islands. Based on this hypothesis, early modern humans from both the southern and northern routes may have reached the Japanese Islands, and lithic assemblages of the Japanese EUP, as well as their shifts during the EUP, could reflect early modern human migrations across Eurasia. Further, several waves of migration to the Japanese Islands of early modern humans to the Japanese Islands could have already occurred during the EUP. This argument adds to previous discussions concerning technological flexibility, suggesting that modern humans as a species demonstrated appreciable flexibility (Yamaoka 2014).

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