FROM GATHERING TO MINING: PREHISTORIC HUMAN ACTIVITIES AROUND OBSIDIAN SOURCES IN CENTRAL JAPAN

NYERSANYAG BESZERZÉS A GYŰJTÉSTŐL A BÁNYÁSZATIG: AZ ŐSKORI KÖZÖSSÉGEK TEVÉKENYSÉGE AZ OBSZIDIÁN NYERSANYAGFORRÁSOK KÖRNYEZETÉBEN JAPÁN KÖZÉPSŐ RÉSZÉN

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Abstract

The present paper discusses changes in obsidian procurement activities and circulation systems between the Upper Palaeolithic and the Jomon Periods. The obsidian source distribution in the Japanese Islands and obsidian provenance analysis in archaeology are overviewed as backgrounds of the study. The archaeological record from the Central Highlands obsidian source area in central Japan suggests that distinct changes in prehistoric human activities and social relations with regard to the obsidian source exploitation occurred. Chief among these were changes 1) in site distribution patterns in and around the Central Highlands, 2) from the gathering of obsidian exposed on the ground surface to the mining of obsidian from underground deposits, 3) from various types of landscape use around the source area to specialized landscape use in mining activities, and 4) from obsidian circulation systems dependent on procurement with high transport costs, which was basically embedded in mobility strategies, to exchange systems with low transport costs based on mining and sophisticated social relations.

Kivonat

Ez a tanulmány az obszidián kitermelés és nyersanyagforgalom változásait mutatja be a felső paleolitikumtól a Jomon kultúra különböző periódusain keresztül. Áttekinti az obszidián nyersanyagforrások jellemzését és az obszidián elterjedését a Japán-szigeteken. A Japán-hegyvidék központi részén található obszidián nyersanyagforrások környezetében tapasztalható változások egyértelműen tükrözik az emberi közösségek életmódjában tapasztalható változásokat. Ezek a változások a következőek: 1) megváltozik a régészeti lelőhelyek elterjedése az obszidián nyersanyagforrások környezetében; 2, a felszínen található obszidián darabok begyűjtésétől a felszín alatti nyersanyagrétegek kitermeléséig jutnak el; 3) a területhasználat módjában megfigyelhető a bányászattal összefüggő tevékenységek előtérbe kerülése és végül 4) a mobilitással összefüggő kevésbé hatékony szállítási stratégiák helyett a bányászattal összefüggő szervezett szállítási rendszerek kerülnek, melyek összességében jóval hatékonyabban oldják meg a nyersanyag eljuttatását a felhasználás helyére

KEYWORDS: UPPER PALAEOLITHIC, JOMON CULTURE, OBSIDIAN EXPLOITATION, MINING, JAPANESE ISLANDS

KULCSSZAVAK: FELSŐ PALEOLITIKUM, JOMON KULTÚRA, OBSZIDIÁN KITERMELÉS ÉS BÁNYÁSZAT, JAPÁN

Introduction

From the perspective of plate tectonics, there are two large volcanic fronts running through the Japanese Islands, one of which is extending parallel to a subduction boundary of the Pacific Plate while the other is extending parallel to that of the Philippine Plate (Kaizuka 1977). Distribution of obsidian sources in the archipelago is widely extended along with the volcanic zones. Because the localities of obsidian sources are limited, the study of obsidian from the perspective of both chemical and instrumental analysis and archaeology has provided significant information, revealing relations among lithic technologies, mobile strategies, exchanges, contacts, and migrations in prehistoric societies. In several regions of the archipelago, obsidian had been used as a high-quality and non-local lithic raw material during the Upper Palaeolithic and the Jomon Periods (the term “Jomon” in Japanese refers to a kind of cord-marking that was used to decorate pottery). The Upper Palaeolithic in the archipelago falls between ca. 38,000 and ca. 16,000 cal BP and the Jomon between ca. 16,000 and ca. 2,800 cal BP (Kudo 2007, Kudo & Kumon 2012). The Jomon lifestyle was characterized by semi-sedentary settlements using dwelling pits. The Jomon subsistence economy was widely dependent on hunting, fishing, and gathering. Plant cultivation and animal domestication, if any existed, were only developed to a limited degree in the Jomon society.

This paper aims to provide information on obsidian sources, sites, and human activities around the sources in prehistoric Central Japan. An overview of the source distribution in the archipelago and an obsidian provenance study closely related to

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archaeology are presented. The activities of hunter-gatherers in the prehistoric sites of Takayama at the Hoshikuso Pass obsidian sources in the Central Highlands of Nagano Prefecture in central Japan are examined. To conclude, the differences and changes in obsidian procurement and circulation systems between the Upper Palaeolithic and the Jomon Periods are discussed. This paper uses the framework of calibrated radiocarbon dates connected to the chronologies of the Upper Palaeolithic industries and the Jomon pottery types compiled by Kudo (2007) and Kudo & Kumon (2012), unless otherwise specified.

Obsidian sources in the Japanese Islands

The Japanese Islands are composed of four main islands, namely, Hokkaido, Honshu, Shikoku, and Kyushu, in order from north to south. Approximately 200 geological obsidian sources have been discovered throughout the archipelago. It has been made clear that they are distinguishable into at least seventy-five source groups based on chemical and instrumental analysis of obsidian, and volcanic geological surveys on the sources. These source groups are further classified into forty-four geographical source areas (Sugihara 2011). There are three main regions in which the obsidian sources are densely distributed. They are the north-eastern part of Hokkaido, central Japan, and the northern part of Kyushu. Although most of the obsidian from these regions was supplied to prehistoric sites distributed within the individual regions, obsidian from the Shirataki and Oketo source areas in Hokkaido was transported to Sakhalin Island during the Late Upper Palaeolithic and the early Holocene (Kuzmin 2010, 2011). Also, Mt. Koshidake obsidian from the northern part of Kyushu has been identified from a microblade industry in the Late Upper Palaeolithic site of Shingbuk in the southern part of Korea (Kim et al. 2007) and from several Holocene sites in the Ryukyu Islands, the southernmost of the Japanese Islands (Obata et al. 2004, 2010).

Prehistoric obsidian industries distributed in central Japan originated from the following five obsidian source areas: the Central Highlands, Kozu Island, Hakone, Amagi, and Mt. Takahara (**Fig. 1**). They are located at altitudes from 0 to 2,000 m above sea level. Obsidian provenance analyses using fission track analysis, neutron activation analysis (NAA), and X-ray fluorescence analysis (XRF) on both geological and archaeological obsidian in central Japan have been conducted since the early 1970s.

Obsidian provenance analysis in archaeology

Pioneering work in the chemical and instrumental analysis of geological obsidian was undertaken by Masao Suzuki in the early 1970s (Suzuki 1970, 1973). Using fission track analysis applied to obsidian artifacts from the multi-layered lithic industries of the Nogawa Site in Tokyo, he was the first to present the changes in obsidian use in the Upper Palaeolithic sequence based on differences in the identified sources (Kobayashi et al. 1971). Ono (1973) has already pointed out the significance of obsidian provenance studies in archaeology and has insisted on the necessity for intensifying new methods to integrate provenance data with archaeological site distribution patterns, chronology, typology, and lithic technologies.

From the perspective of non-destructive procedures, an analytical method using an energy dispersive X-ray fluorescence (EDXRF) device in addition to NAA has become the mainstream in obsidian provenance studies since the late 1970s. Although this trend led to an increase in attention being paid to prehistoric trades or exchanges by the analytical chemist themselves (e.g., Suzuki 1977, 1985; Warashina & Higashimura 1988), the method used for interpreting prehistoric behaviors remained a simple one, in which the identified source and the location of the site which yielded the analyzed artifact were directly connected by a straight line. Archaeological interest focusing on the relations between obsidian distribution patterns and the organization of regional hunter-gatherer groups in the Upper Palaeolithic appeared in the latter half of 1980s as well (Inada 1984; Tamura 1987; Kanayama 1988, 1990). According to an increase in the amount of Kozu Island obsidian identified from the Upper Palaeolithic and Jomon occupation sites, Oda (1981) was the first to systematically argue on the prehistoric seafaring between Kozu Island and the mainland of Honshu. It seems that the quantity of the obsidian provenance data at the time, however, did not satisfy archaeological purposes, mainly because a few artifacts were arbitrary selected from a lithic assemblage in most cases.

Ikeya and Mochizuki (1994) have undertaken XRF analysis to integrate obsidian provenance data with archaeological research designs. They aimed at analyzing as many obsidian artifacts as possible from a single occupation level using the non-destructive procedure of the EDXRF. Mochizuki et al. (1994) demonstrated a pattern of obsidian lithic distribution based on the identified sources in the Early Upper Palaeolithic assemblage from the Doteue site in Shizuoka Prefecture. The pattern showed several concentrations according to the identified sources, and indicated that there are mutual relations among the concentrations. They claimed that detailed chemical and instrumental analysis of obsidian lithic distribution is capable of revealing not only the mobility of the residential group but also how the group was organized at the site.

Table 1.: Obsidian provenance data of the early part of the Early Upper Palaeolithic in central Japan

1. táblázat: Obszidián proveniencia adatok a korai felső paleolitikumból a Japán-hegyvidék középső részén

Regions	Sources										Obsidian total (analysis)	Obsidian total (assemblage)	analysis/ assemblage	Num. of sites
	Central Highlands		Mt.Takahara		Hakone		Amagi		Kozu-Onbase					
Northern Kanto	617	67.7%	280	30.7%	2	0.2%	2	0.2%	11	1.2%	912	Not available	-	14
Eastern Kanto	556	71.4%	57	7.3%	1	0.1%	0	0.0%	165	21.2%	779	2,630	29.6%	9
Western Kanto	271	52.4%	11	2.1%	60	11.6%	149	28.8%	26	5.0%	517	Not available	-	14
Ashitaka	385	14.4%	0	0.0%	1,203	44.9%	464	17.3%	629	23.5%	2,681	4,047	66.2%	15
Lake Nojiri	11,160	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	11,160	17,056	65.4%	15
Total	12,989	80.9%	348	2.2%	1,266	7.9%	615	3.8%	831	5.2%	16,049	-	-	67

Also, Ikeya and Mochizuki (1998) compiled lithic raw material use and obsidian provenance analysis data, and examined the changes of obsidian use in the Upper Palaeolithic sequence in the area at the foot of Mt. Ashitaka, Shizuoka Prefecture. They confirmed that the use of Kozu Island obsidian in the area dates back to as early as the beginning of the Early Upper Palaeolithic. The validity of the identification by the EDXRF between the geological obsidian of Kozu Island and archaeological obsidian has been cross-checked by NAA (Ikeya et al. 2005).

On the basis of provenance data assured in quantity and obtained either from a single occupation level or a geographic area, the archaeological research designs that examine the relations between obsidian procurement activities and the mobility strategies of prehistoric populations have been developed since the latter half of 1990s (e.g., Mochizuki and Tsutsumi 1997, Tsutsumi 2003, Shimada 2008, Ikeya 2009, Tsutsumi 2010). Recently, Serizawa et al. (2011) compiled all of the data from obsidian provenance analyses in the Kanto plain (Tokyo Metropolis, Kanagawa, Chiba, Saitama, Gunma, Ibaragi, and Tochigi Prefectures). According to the data, the total number of identified obsidian artifacts stands at 38,235 pieces from the Upper Palaeolithic and 41,178 pieces from the Jomon lithic industries.

The beginning of obsidian use in central Japan

The obsidian provenance analyses have identified the sources of 16,049 obsidian artifacts from the lithic industries of central Japan in the early part of the Early Upper Palaeolithic (eEUP for short), dated to the interval between ca. 38,000 and ca. 35,000 cal BP (**Table 1**). The geographical features and the density of site distribution in the eEUP divide the Kanto district into three archaeological regions, namely, northern, eastern, and western Kanto (**Fig. 1**). In addition, the Ashitaka region is located in the southernmost part of central Japan, and the Lake Nojiri region is in the northernmost part of central Japan. **Table 1** and **Figure 1** illustrates the ratio of the identified obsidian sources among the five archaeological regions in the eEUP.

It can be pointed out that obsidian transported from every source area by the eEUP populations was found to be distributed over 80 km from the sources. In particular, obsidian from Kozu Island, the distribution of which is concentrated in the Ashitaka area and in east Kanto, was obviously transported across the ocean. Kozu Island has never been connected to the coastal areas of Honshu by any land bridges, even in the LGM (at least 30-40 km away from Honshu). Recently, radiocarbon dates and provenance data obtained from the obsidian assemblage of the Ide-maruyama site in the Ashitaka area revealed that obsidian exploitation in both the Central Highlands and on Kozu Island dates back to 37,000-38,000 cal BP (Takao & Harada 2011).

Figure 1. also shows that only the Central Highlands obsidian was distributed throughout central Japan. This phenomenon is explained by the notion that the mobility strategies of the eEUP populations were planned to pass through the Central Highlands, having used the place like a hub that connected various residential areas. The author believes that far-reaching mobility strategies of the eEUP overlapped with the seasonal migration routes of large now-extinct herbivores, such as Naumann's elephants (*Palaeoloxodon naumanni*) and Yabe's giant deer (*Sinomegaceros yabei*). Several researchers have claimed that their seasonal migration route through the central Japan of the Late Pleistocene was extended between the coastal area of the Sea of Japan and the Kanto Plain via the Lake Nojiri site group, the north side of the Central Highlands, and Usui-toge (the Usui Pass) (Otaishi 1990, Ono 2001) (**Fig. 1**).

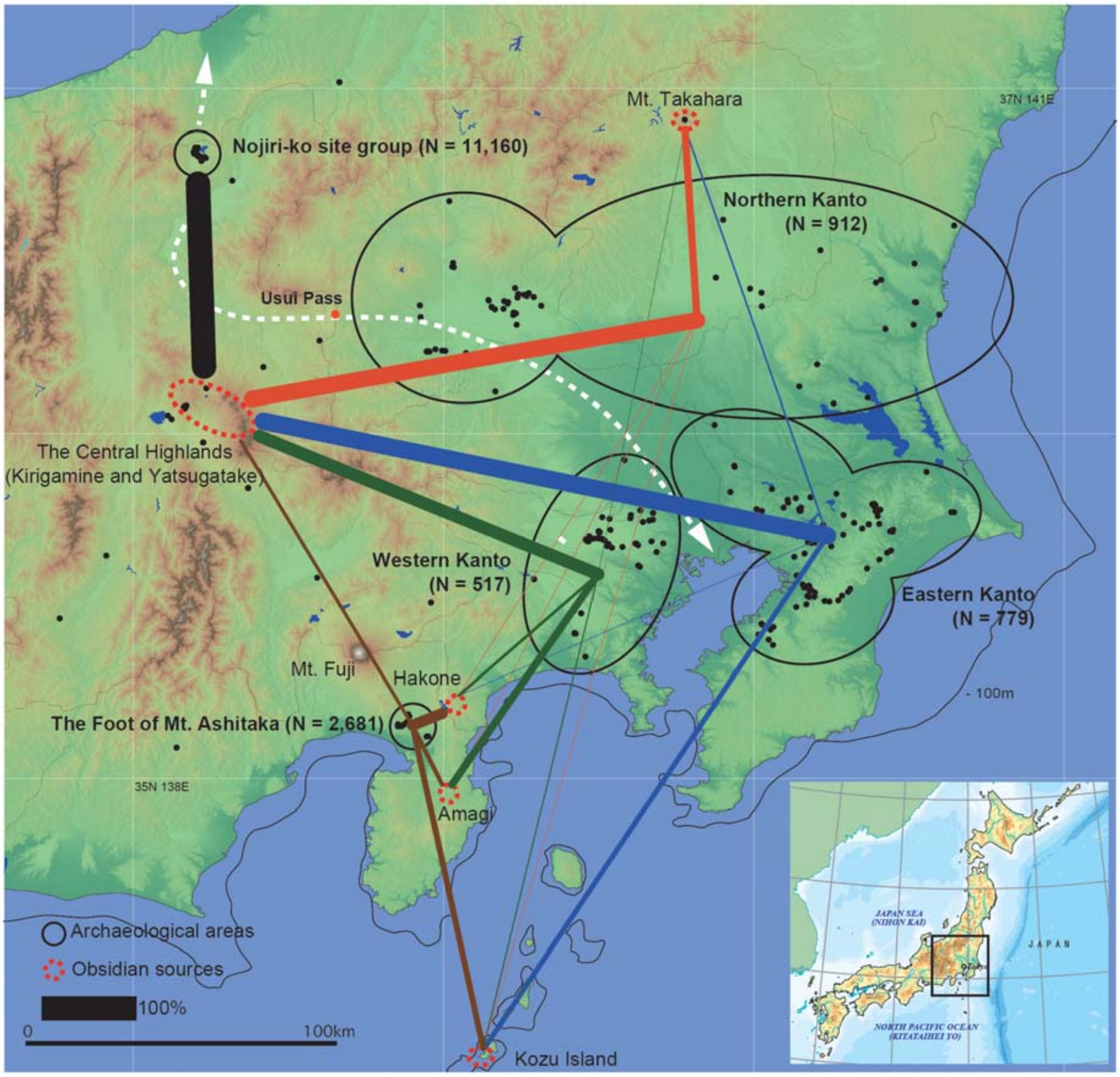

Fig. 1.: Map of sites and obsidian distribution in the eEUP (~40 ka-35 ka cal BP) in central Japan. Black dots: eEUP lithic industries. The bars in each archaeological area show the ratio of obsidian artifacts classified into five source areas by provenance analysis (XRF, NAA). "N" indicates the number of obsidian artifacts analyzed as of 2011 (**Table 1.**). White dotted line: supposed seasonal migration route of extinct large herbivores in the Late Pleistocene (Otaishi 1990, Ono 2001)

1. ábra: Obszidián elterjedése a legkorábbi korai felső paleolitikum (eEUP) lelőhelyeken (~40 ka-35 ka cal BP) Japán középső részén. Jelkulcs: az eEUP kőiparok elterjedését fekete pöttyök jelölik. A vonalas diagram a régészeti lelőhelyeknél az obszidián eszközök arányát mutatja, öt nyersanyagforrás-területhez sorolva őket (XRF, NAA vizsgálattal azonosítva). "N" mutatja a vizsgált obszidián eszközök számát (2011-ig, ld. **1. táblázat**). Fehér pöttyözött vonallal jelölve a késő pleisztocén nagy növényevők szezonális vándorlási útvonala (Otaishi 1990, Ono 2001)

Accordingly, the exploitation of the Central Highlands obsidian was essentially embedded in the mobility strategies of the eEUP populations. As a result, the Central Highlands obsidian was supplied over all of the residential areas.

Since the beginning of obsidian source exploitation in the eEUP, the Central Highlands had served as the core region of obsidian supply during the Upper Palaeolithic and the Jomon Periods. The archaeological record of the Central Highlands will be examined in the sections below to reveal the activities of the Upper Palaeolithic and Jomon peoples at specific sources and how they obtained obsidian nodules.

Sources and sites in the Central Highlands

Sources and site distribution

The obsidian sources in the Central Highlands of Nagano Prefecture, over 20 of which have been mapped so far, are scattered throughout the mountainous areas of Kirigamine and Yatsugatake

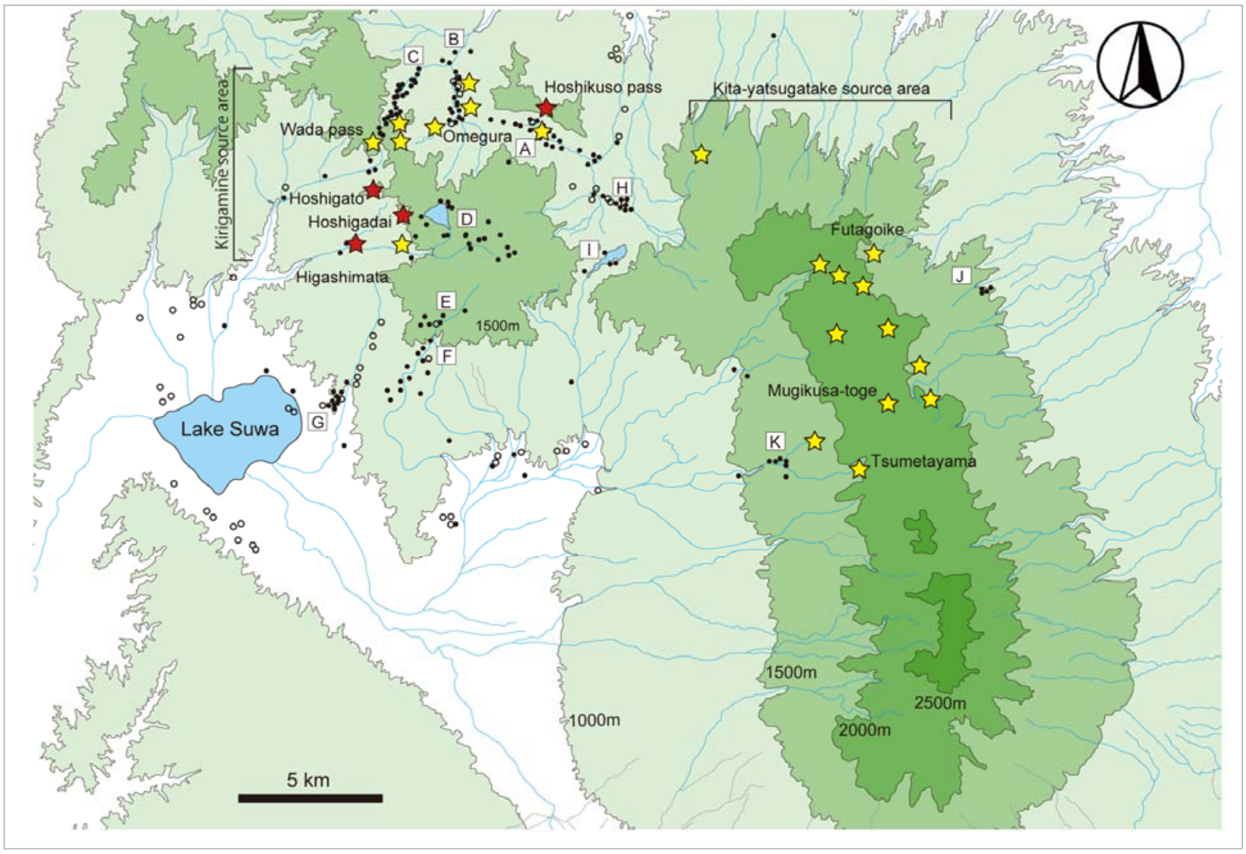

Fig. 2.: Distribution map of prehistoric sites and major obsidian sources in the Central Highlands of Nagano Prefecture. ●: Upper Palaeolithic sites; ○: Jomon sites; A-F: Upper Palaeolithic site groups (A: Takayama, B: Omegura, C: Wata-toge, D: Yashima, E: Ikenokurumi, F: Jakoppara, G: East Lake Suwa, H: Warehashi, I: Ikenotaira Lake Shirakaba, J: Ikenotaira, K: Shibukawa); yellow stars: major obsidian sources; red stars: sources with a Jomon mining site

2. ábra: Őskori lelőhelyek elterjedése és a nagyobb obszidián források a Japán-hegyvidék középső részén Nagano prefektúra területén. Jelkulcs: ●: felső paleolit lelőhelyek, ○: Jomon lelőhelyek; A-F: felső paleolit lelőhely csoportok (A: Takayama, B: Omegura, C: Wata-toge, D: Yashima, E: Ikenokurumi, F: Jakoppara, G: East Lake Suwa, H: Warehashi, I: Ikenotaira Lake Shirakaba, J: Ikenotaira, K: Shibukawa); sárga csillagok: nagyobb obszidián források; vörös csillagok: nyersanyagforrások Jomon kori bányahellyel

at altitudes between 1,200 and 2,000 m above sea level (**Fig. 2**). According to the classification of the sources, based on petrographical observation and XRF elemental analysis for the Central Highlands obsidian by Sugihara (2011), these sources are distinguishable into six source groups (Nishi-kirigamine, Wada, Takayama, Omegura, Mugikusa/Tsumetayama, and Yokodake). The distribution of the source groups can be further divided into two geographical areas (Kirigamine and Kita-Yatsugatake).

In the area near and around the sources, a large number of Upper Palaeolithic and Jomon sites have been discovered since the 1950s. When site distribution patterns in the area are compared between the Upper Palaeolithic and the Jomon Periods, there is a stark contrast with regard to landscape use (**Fig. 2**). The Upper Palaeolithic sites are obviously concentrated in a high altitudinal zone above 1,000 m particularly close to the sources. The Jomon settlements with dwelling pits tend to be distributed on hill-slopes at some distance from the sources in a lower altitudinal zone below 1,000 m. Also, general surveys have brought to light that at least four large extended underground obsidian mining sites from the Jomon Period exist at the sources. They are the mining sites of Hoshikuso Pass, Hoshigato, Hoshigadai, and Higashimata (Anbiru et al. 1999, Miyasaka & Tanaka 2008).

Takayama prehistoric site group at the Hoshikuso pass obsidian sources: an overview

Early excavations in the Central Highlands were often conducted, until the 1970s, in only small test-pits, and the majority of artifacts were not collected by a systematic excavation procedure. Since 1984, a research group for the Takayama sites headed by Mitsunori Tozawa and Masao Anbiru of Meiji University, Tokyo has conducted general surveys

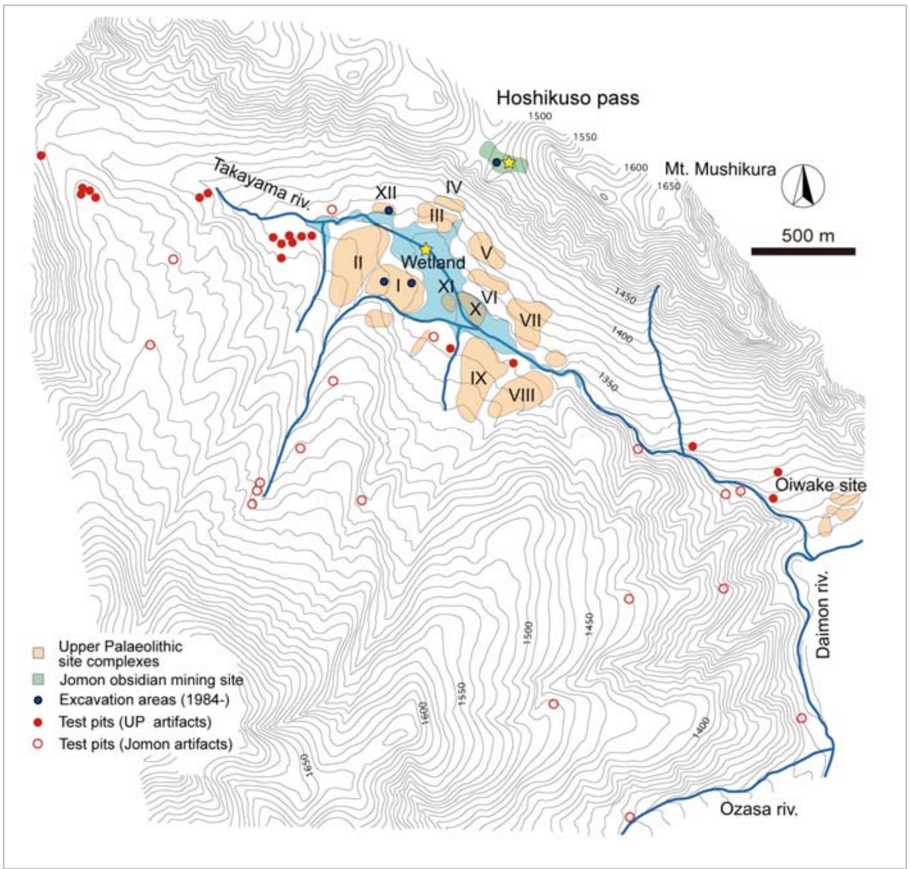

Fig. 3.:

Prehistoric site group of Takayama in Nagawa Town, Nagano Prefecture, Japan. Yellow stars: obsidian sources. Modified from Anbiru & Shimada 2001: Fig. 2

3. ábra:

A Takayama lelőhely-csoport Nagawa környékén (Nagano prefektúra). Az obszidián nyersanyag-források sárga csillaggal jelölve. Anbiru & Shimada 2001: Fig. 2 nyomán.

and controlled excavations at the Takayama site group. The author has been a member of the team since 1989. The site group is located around the obsidian sources of the Hoshikuso Pass (**Fig. 2: A, Fig. 3**). The sources are classified under the source group of "Takayama" by the above-mentioned Sugihara scheme.

Obsidian nodules buried within deposits of the slope extending from the Hoshikuso Pass to the top of Mt. Mushikura, and of the wetland and the riverbed along the Takayama River are observable at present (Tozawa et al. 1989, Anbiru et al. 1999). The geological research, including boring surveys, has revealed that these obsidian deposits originated from the pyroclastic flow of eruptions in 0.27 Ma and 0.87 Ma (Sugihara & Danbara 2007).

With the systematic surface surveys conducted by the research group in 1986-1987, the Upper Palaeolithic site complexes have been identified (Tozawa et al. 1989, Anbiru et al. 2003a). The 12 Upper Palaeolithic site complexes (Takayama I to XII sites) around the wetland are represented by the spatial distribution of the surface collections, and are distinguished from each other by small buried valleys (**Fig. 3**). Nearly all the surface collections (N = 6,122) have been composed of Palaeolithic artifacts, though 15 arrowheads and a few fragments of Jomon pottery have been found. Of these site complexes, the excavations that focused on site complex-I have revealed Upper Palaeolithic workshops for obsidian reduction (**Fig. 4**). The representative workshops in site complex-I are Locality M (abbreviated as TI-M in the text below) and Locality S (abbreviated as TI-S in the text below), excavated in 1984 and 1989, respectively. Additionally, at the eastern margin of the site group, the place where the Takayama River runs into the Daimon River, the multi-layered Upper Palaeolithic occupation site of Oiwake was excavated by the Nagato Town Board of Education in the years 1995-1998 (**Fig. 3**) (Otake & Katsumi 2001).

During the above-mentioned surface surveys, the research group discovered that numerous surface depressions like moon craters with diameters of 5-10 m were densely scattered on the mountain slope extending from the Hoshikuso Pass (Tozawa et al. 1989) (**Fig. 3**). In 1991, the team first excavated surface depression No. 1 (abbreviated as SD No. 1 in the text blow) and unearthed numerous small pieces of obsidian, laminated soil layers that were piled artificially over 2 m deep, pottery assigned to the Late Jomon packed between the layers, vertical profiles of pits, and obsidian nodules buried within the white clay-like pyroclastic deposit at the bottom of the excavation trench. The bottom part of the pits reached the obsidian deposit (**Fig. 7**: **Photos 1, 2, 3**).

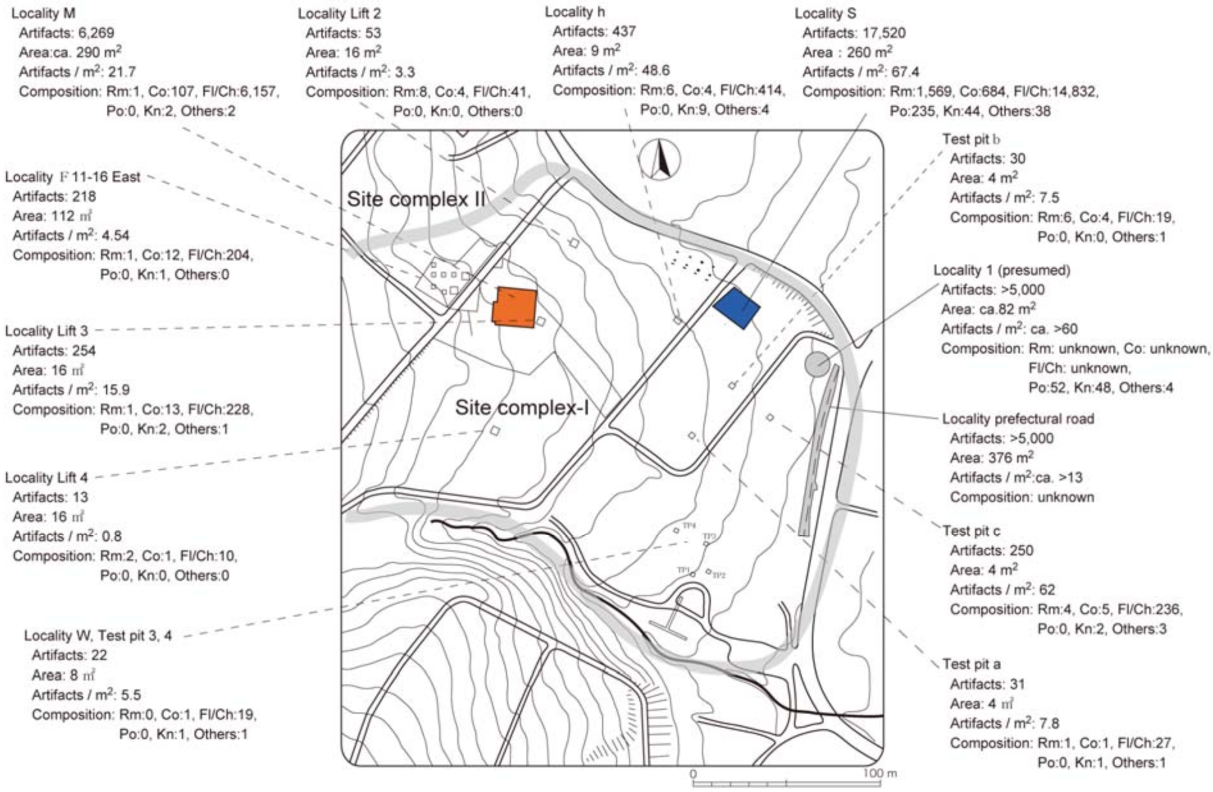

Fig. 4.: Takayama site complex-I and excavation areas (1966-) (Shimada, 2007). Dotted lines: backed-point industries; solid lines: spear-point industries; Rm: raw materials; Co: cores; Fl/Ch: flakes and chips; Po: spear-points; Kn: backed-points. Data of lithic assemblages after Miyasaka & Miyasaka 1966, Tozawa et al. 1989, Tozawa & Anbiru 1991, Otake & Katsumi 2001

4. ábra: A Takayama lelőhelycsoport I sz. lelőhelye és az ásatási terület (1966-) (Shimada, 2007). Szaggatott vonal jelöli a tompított hátú hegyekkel jellemezhető iparokat, folyamatos vonal a lándzsahegyekkel jellemezhető iparokat. További jelek: Rm: nyersanyagdarab; Co: magkő; Fl/Ch: szilánk és pattinték; Po: lándzsahegy; Kn: tompított hátú hegy. Miyasaka & Miyasaka 1966, Tozawa et al. 1989, Tozawa & Anbiru 1991, Otake & Katsumi 2001 adatainak felhasználásával.

Hence, the excavation verified that the pits were used for mining obsidian and were filled with mining spoils, and that the crater-like shape of SD No. 1 was formed by both the underground obsidian mining activities and the disposal actions of the mine spoils by at least the Late Jomon people (Anbiru et al. 1999). Measurement surveys of the mining site conducted in 1992-1993 and 1998-1999 revealed that 194 surface depressions are scattered over an area of ca. 45,000 m^2 (Anbiru & Shimada 2001) (**Fig. 7: Map**).

Activities of prehistoric hunter-gatherers in the Takayama site group

Upper Palaeolithic workshops and occupations

TI-M yielded 6,269 lithic artifacts (6,266 obsidian and three other raw materials) comprising one large-sized lithic concentration (Tozawa et al. 1989) (Figs. 4, 5). The lithic assemblage is characterized by a developed blade technique and intensive production of obsidian blades. Only two finished stone tools have been unearthed. Although only one piece of an obsidian nodule has been discovered at the site, the analysis of the lithic technology indicates that various forms of angular chunks 8-30 cm in length basically represent the nodules for blade production. No hearth has been discovered from T1-M. Obsidian provenance analysis on the TI-M assemblage has indicated a convergence to the Wada-Takayama group (corresponding with the Takayama source group by Sugihara scheme) (Kobayashi 2001). These features of TI-M suggest that the lithic assemblage was formed by a short-term encampment in association with intensive preparation of lithic blanks and blade cores based on the acquisition of the Takayama obsidian from the wetland. The interpretation is also supported by the fact that the minimum amount of nodules necessary for blade core reduction at that location was brought into the site.

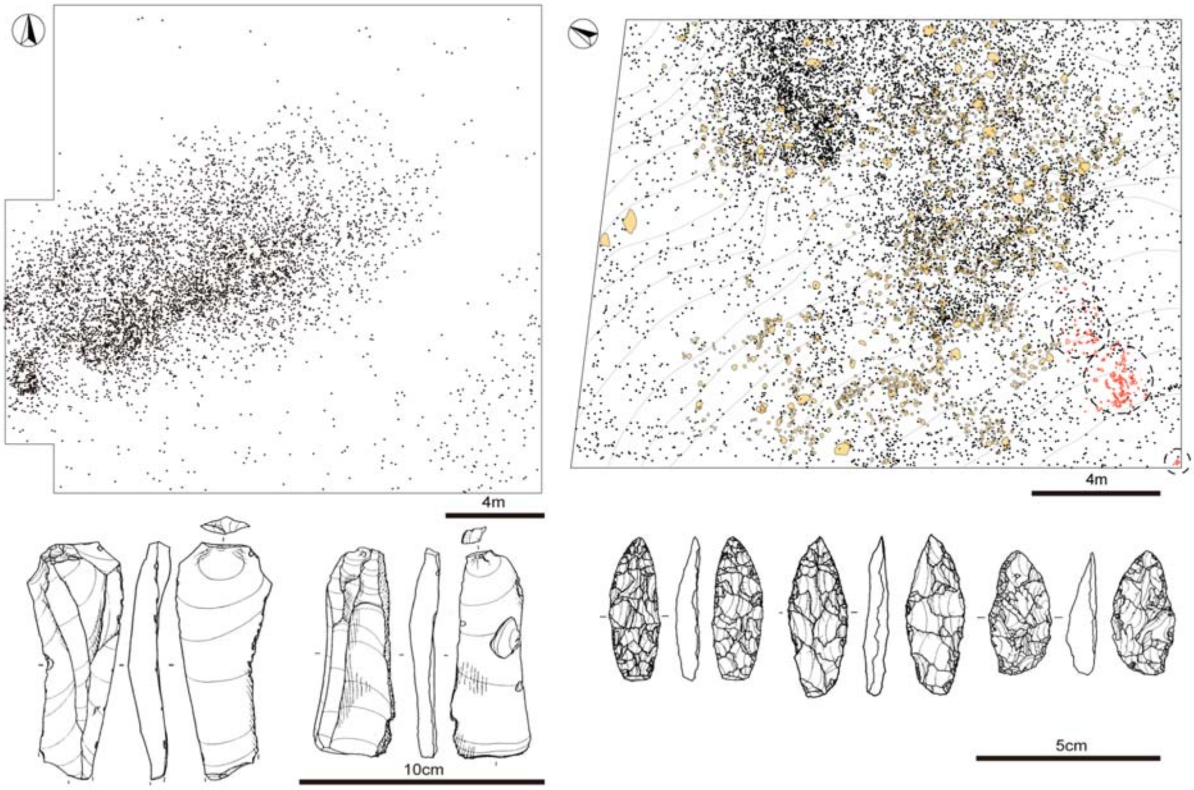

Fig. 5.: Distribution of artifacts from Takayama site complex-1, Locality M (left) and Locality S (right). Dots: lithic artifacts (brown: cobbles; red: stone hearths). After Tozawa et al. 1989, Tozawa & Anbiru 1991

5. ábra: Leletsűrűség és megoszlás a Takayama lelőhelykomplexum 1 sz. lelőhelyén, M (balra) és S (felületek). A kőeszközöket pontok jelölik, barnával a kavicsokat, vörössel a tűzhelyfoltokat jelöltük Tozawa et al. 1989, Tozawa & Anbiru 1991 nyomán.

No radiocarbon dates have been obtained from the site, but the techno-typological analysis based on the Upper Palaeolithic chronology in the Kanto Plain indicates that TI-M can be assigned to the final stage of the Early Upper Palaeolithic ca. 27,000-28,000 cal BP. The proliferation of obsidian backed-point industries on the Kanto Plain, which is parallel to TI-M, immediately prior to LGM, indicates that a large amount of the obsidian lithic blanks and cores was supplied from lithic workshops, including TI-M, to consumption areas far from the Central Highlands (Anbiru 1991).

From the 260 m^2 excavation area at TI-S, 17,520 artifacts have been recovered, including 189 pieces of unfinished spear-points accounting for 80% of the 235 spear-points in total. These points were made by bifacial, unifacial, or partial retouch (Tozawa & Anbiru 1991) (**Figs. 4, 5**). The dominant nature of the unfinished pieces in the composition of the stone tools demonstrates that TI-S can be recognized as a typical lithic workshop strongly related to both the production and the supply of spear-points. In total, 1,569 unprocessed obsidian nodules have been discovered from the site. The analysis of the lithic technology at TI-S showed that a wide variety of nodule shapes, from tablet to angular chunks, were used for spear-point production and core reduction.

The large-sized lithic concentration at TI-S was accumulated through recurrent site use. This is suggested by the existence of three stone hearths that show differences in stratigraphic level from each other, as well as by the obsidian provenance data obtained from TI-S that demonstrate obsidian was exploited not only from Takayama but also from multiple sources in the Central Highlands (Kobayashi, ibid.). These facts indicate that the tool makers moved about among the sources of the Central Highlands and visited TI-S intermittently for spear-point manufacturing, and that the recurrent site use continued for a prolonged time. A large number of the selected obsidian nodules remained at TI-S support this interpretation as well.

No radiocarbon dates have been obtained from TI-S but the techno-typological analysis based on the Upper Palaeolithic chronology in the Kanto Plain convincingly shows that TI-S can be assigned to the spear-point industries in the middle part of the Late Upper Palaeolithic ca. 20,000-23,000 cal BP.

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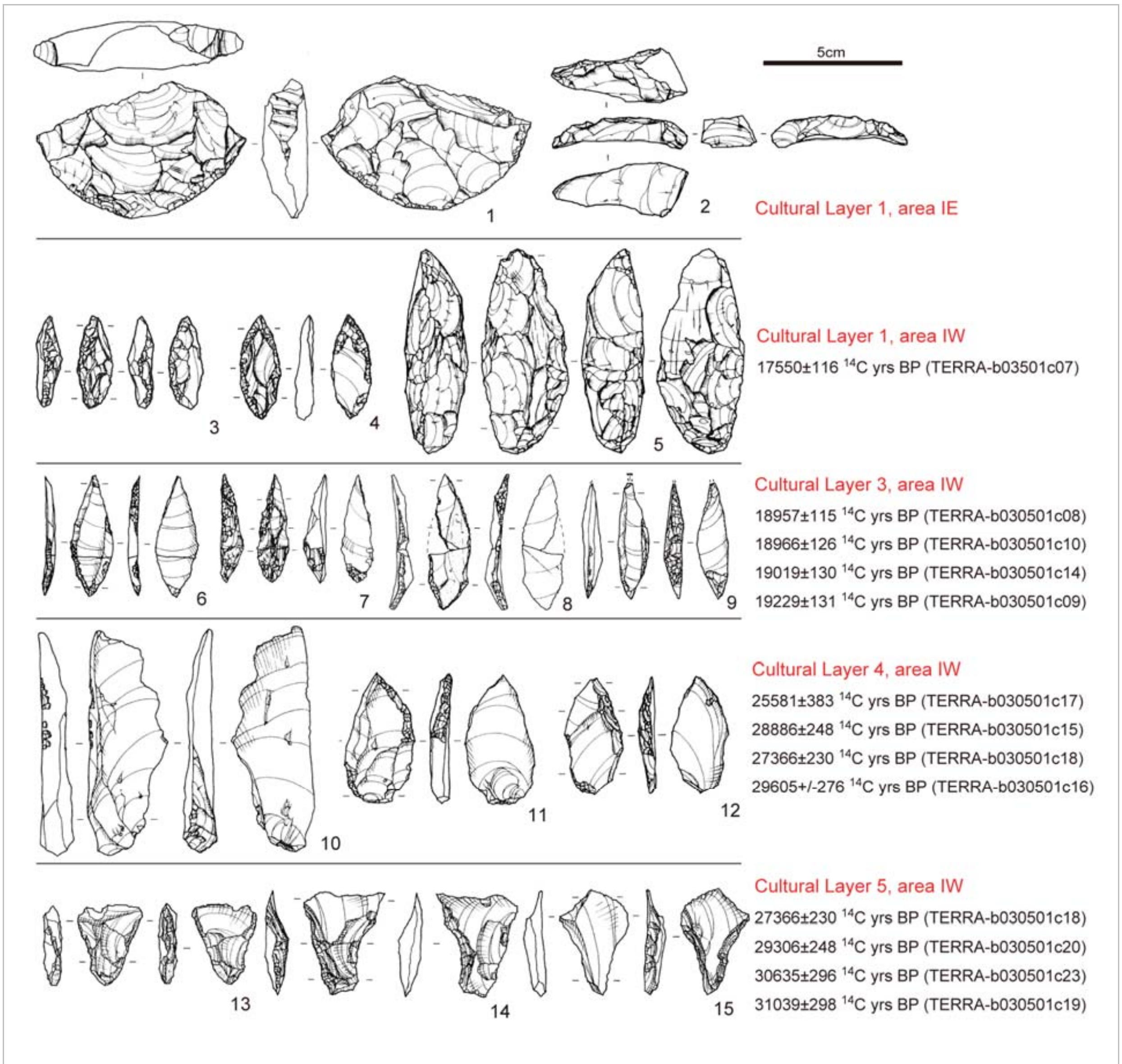

Fig. 6.: Cultural layers, lithic assemblages and radiocarbon dates from Oiwake site. 1: microblade core with platform created through spall removal; 2: platform preparation flake; 3-5: spear-points; 6-12: backed-points; 13-15: trapezoids. After Otake & Katsumi 2001, Yoneda 2001

6. ábra: Oiwake lelőhely kultúrrétegei, kőipar és radiokarbon koradatok. 1: mikropenge magkő kialakítása; 2: platform előkészítő szilánk; 3-5: lándzsahegyek; 6-12: tompított hátú hegyek; 13-15: trapezoid eszközök. Otake & Katsumi 2001, Yoneda 2001 nyomán.

Actually, obsidian spear-points and a large amount of obsidian nodules from the Central Highlands were supplied to the spear-point industries in the Kanto Plain (Anbiru 1991; Shimada 2008).

Not only large lithic workshops but also typical occupation sites are distributed around the Takayama site group. The multi-layered site of Oiwake is situated at the eastern margin of the site group about 2 km from the source of the wetland (**Fig. 3**). The Oiwake lithic industries have convinced us that the landscape use in the mountain range of the Central Highlands was maintained from the beginning of the Early Upper Palaeolithic to the final stage of the Late Upper Palaeolithic between ca. 35,000 and ca. 17,000 cal BP (Otake & Katsumi 2001) (**Fig. 6**). Five occupation levels of the Upper Palaeolithic with secure stratigraphic positions and radiocarbon determinations have yielded a trapezoid industry (ca. 29,000-31,000 ^{14}C BP); a backed-point industry before LGM (ca. 27,000-29,000 ^{14}C BP); a backed-point industry after LGM (ca. 19,000 ^{14}C BP); a spear-point industry (ca. 17,000 ^{14}C BP); and a microblade industry with the Yubetsu technique (no radiocarbon date but the chronological framework indicates 17,000-18,000 cal BP) (dates after Yoneda 2001).

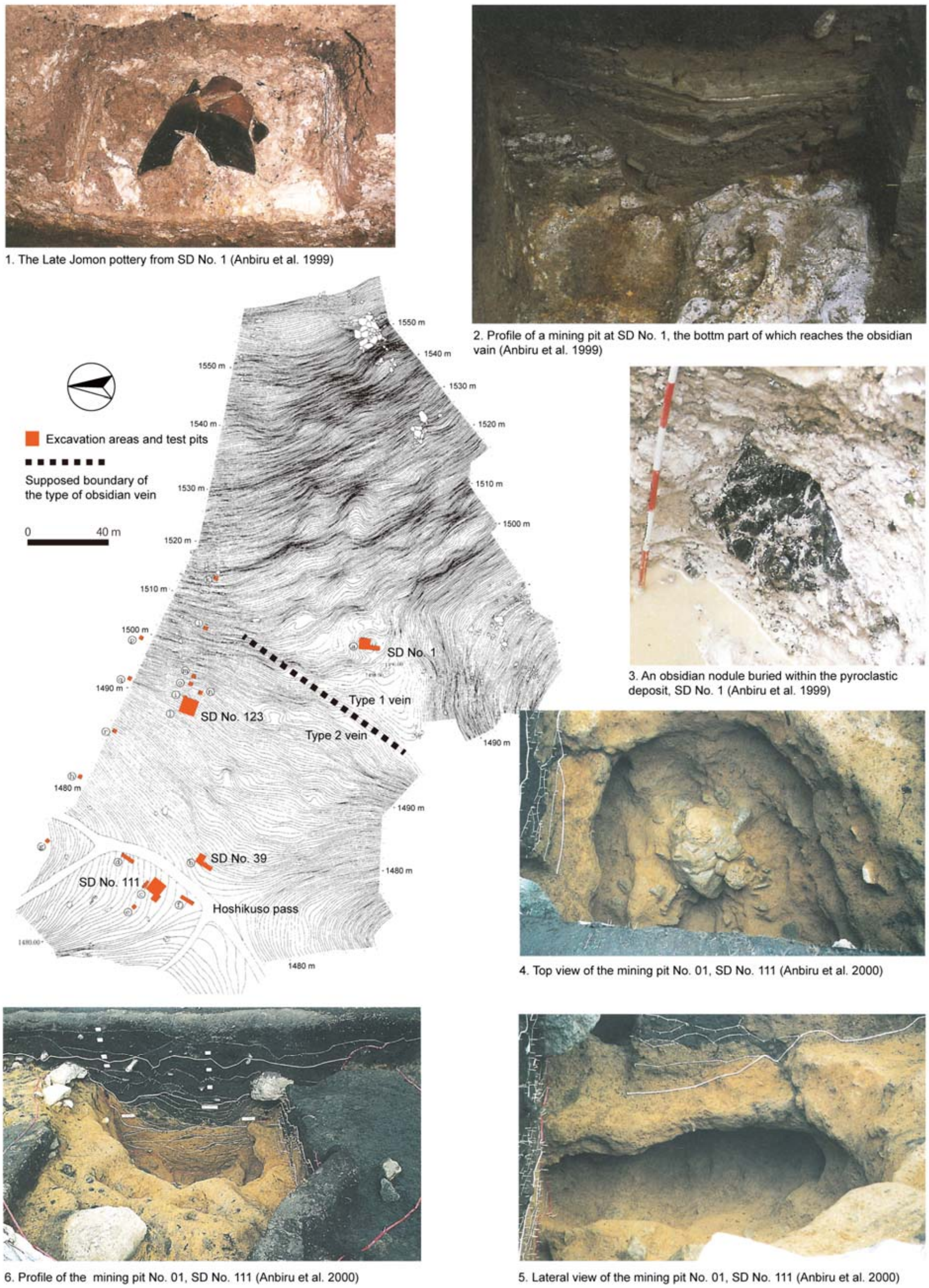

Fig. 7.: Jomon mining site of Hoshikuso Pass in Nagano Prefecture, Japan. The survey map is partially modified from Anbiru & Shimada 2001.

7. ábra: Hoshikuso-hágó, Jomon kori bányahely (Nagano prefektúra). A térkép Anbiru & Shimada 2001 nyomán készült.

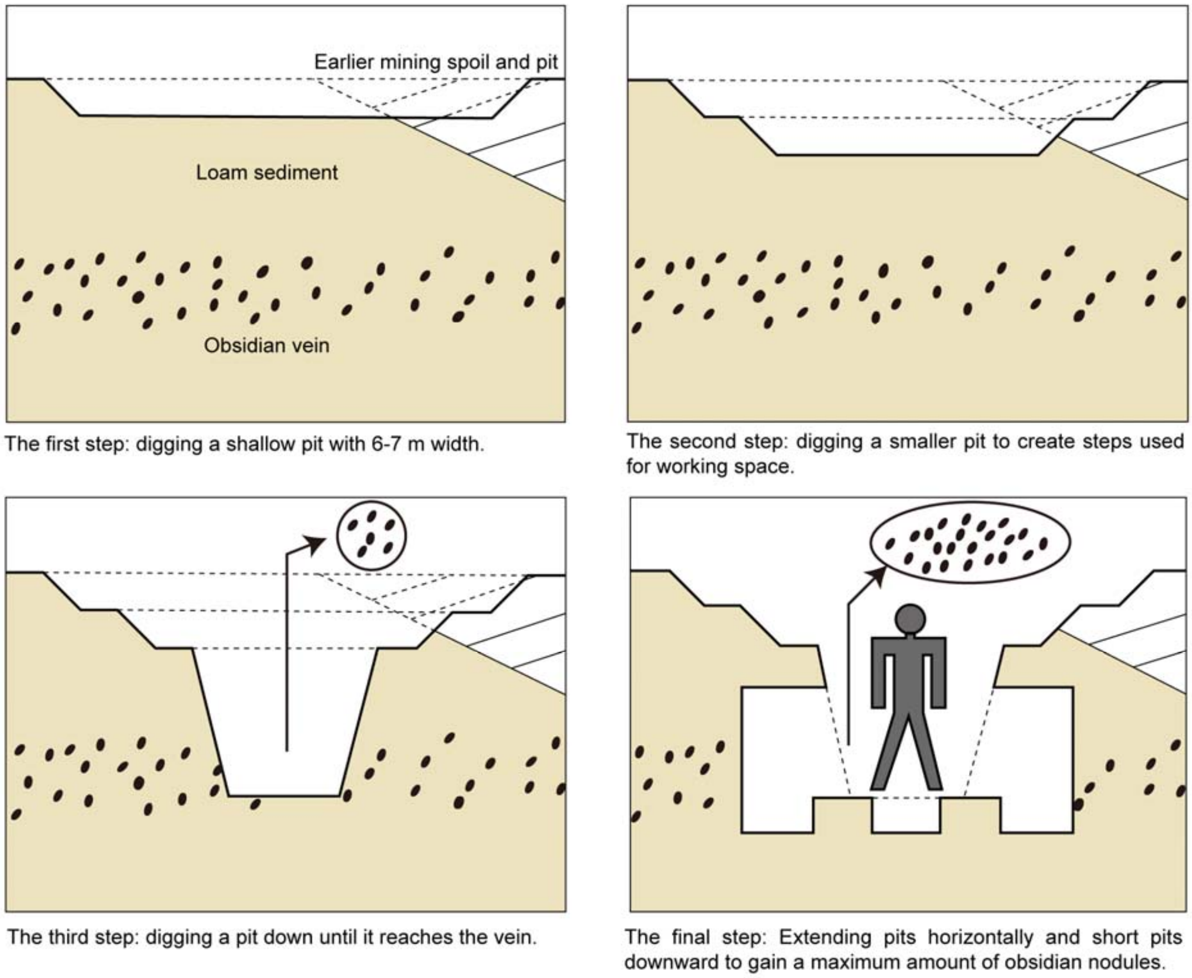

Fig. 8.: Schematic reconstruction of a sequence of mining based on the excavations of mining pit No. 01 at SD No. 111 located at the flat area of Hoshikuso Pass. Modified from Anbiru et al. 2000: Fig. 34

8. ábra: A bányászat folyamatának sematikus rekonstrukciója a Hoshikuso-hágó területén a SD 111 sz. lelőhely 1. sz. bányagödre alapján. Anbiru et al. 2000: Fig. 34 nyomán

Several hundreds of stone tools and debitage, and regular-sized lithic concentrations comprising each occupation level indicate that temporary encampments with subsistence activities including obsidian procurement existed in the source area.

Jomon mining activities

The term 'mining' used in this paper refers to a series of activities undertaken to dig out stone nodules for stone tool manufacturing from underground deposits by digging pits or cutting slopes that require the moving of a certain amount of soil.

Two types of field occurrence of obsidian nodules that prehistoric mining activity pursued have been identified at the mining site of the Hoshikuso Pass. The obsidian occurred within the white clay-like pyroclastic deposit over 2-3 m below the present ground surface is the first type discovered by the excavations of SD No. 1 (Anbiru et al. 1999). The pyroclastic deposit involving the type-1 obsidian deposit seems to show the primary sedimentary structure (**Fig. 7: Photo 3**). The second type of obsidian deposit occurred within the loam sediment, which was discovered by the excavations of SD No. 39 and SD No. 111 (Anbiru et al. 2000) (**Fig. 7: Map**). It appears that the type-2 obsidian deposit represents the secondary deposition caused by landslides, and was originated from the type-1 obsidian deposit (**Fig. 7: Photo 5** shows the loam layer containing the obsidian nodules). Additionally, Upper Palaeolithic spear-point industries have been discovered from the loam sediment at the Hoshikuso Pass as well (Anbiru & Shimada 2001). The distribution of the two types of obsidian deposit is supposed to be separated somewhere around the middle part of the mining site (**Fig. 7: Map**).

A sequence of the mining activity reconstructed from the excavations of mining pit No. 01 at SD No. 111 during 1995-1997 is as follows (Anbiru et al. 2000) (**Fig. 7: Photos 4, 5, 6; Fig. 8**): Before the mining, Jomon miners selected an area to dig a new pit. The new mining pit was dug partially overlapping a former mining pit filled with mining spoils, because this implied that the obsidian deposit existed underground (here, a type-2 deposit). As the first step, the miners dug a shallow pit of 6-7 m in diameter. Next, a somewhat smaller pit than that dug in the first step was dug to create steps used for the working space (**Fig. 7: Photo 6**). Then, a pit of 1.5-2.0 m in depth from the ground surface was dug, and miners could reach the obsidian deposit. Finally, the miners effectively extended pits in a horizontal direction and dug short pits downward to acquire a maximum amount of obsidian nodules (**Fig. 7: Photos 4 and 5**). Apparently, the mining activity required collaborative work by an organized task group.

Typological analysis of Jomon pottery obtained from the excavation of mining pit No. 01 has shown convincingly that the earliest mining activities date back to ca. 12,000 cal BP in the late part of the Incipient Jomon (Anbiru et al. 2000). Radiocarbon dates of ca. 3,500 ^{14}C BP have been recently obtained from charcoal adhering to several fragments of the Late Jomon pottery from SD No. 1 (Otake 2011). However, in order to reconstruct the whole duration of mining activities with confidence, dates obtained so far are insufficient. Although pottery that belongs to the Incipient and Early Jomon has been obtained from the mine spoils of SD No. 1 as well (Anbiru et al. 1999), its relations with mining pits have not yet been made clear. Pottery of the Early and Final Jomon has been discovered from excavation areas at other Jomon obsidian mining sites located at the Hoshigato and Higashimata sources (Miyasaka & Tanaka 2008). Only a small number of the observed surface depressions have been excavated. Further excavations and date determinations of the mining activities are still required.

Yamashina (2011) argued on the selection of obsidian nodules at the mining site of Hoshikuso Pass. He revealed that there are significant relations among the composition of sizes among the nodules contained in the deposit, the discarded nodules recovered from the mining spoils, and the stored nodules at the settlements around the source area, which indicate the selecting of obsidian nodules along with the mining. While primary processing of obsidian nodules occurred on a large scale in the vicinity of mining pit No. 01 at SD No. 111 in the Incipient Jomon (Anbiru et al. 2000), the subsequent mining activities at the mining pits of Higashimata in the Early Jomon, and at those of the Hoshikuso Pass in the Late Jomon show negative association with lithic workshops (Anbiru et al. 1999, Miyasaka & Tanaka, ibid.). The primary processing activities at the mining site reappeared at the mining pits of Hoshigato in the Final Jomon (Miyasaka & Tanaka, ibid.).

Changes in obsidian source exploitation between the Upper Palaeolithic and the Jomon

Given that prehistoric human activities in an area lead to a certain type of site distribution pattern, the distinct change in site distribution patterns between the Upper Palaeolithic and the Jomon in the Central Highlands mentioned earlier reflects the changes in obsidian procurement activities. This section examines this issue from the perspective of procurement technologies, landscape use, the organization of groups, and the obsidian circulation systems.

Procurement technology

The Upper Palaeolithic people collected obsidian nodules cropping out at procuring spots such as riverbeds. According to the results of the excavation of SD No. 123 at the mining site of the Hoshikuso Pass in 2002 (**Fig. 7: Map**), which aimed at revealing the relations between the Upper Palaeolithic spear-point industries at the Hoshikuso Pass mentioned in the previous section and the type-2 obsidian deposits, there has been no evidence of mining activities related to the lithic concentrations of the spear-point assemblage discovered by the excavation (Anbiru et al. 2003b, Shimada et al. 2006). Basically, the gathering of obsidian nodules from ground surfaces at the procuring spots is characteristic of Upper Palaeolithic obsidian procurement.

In contrast, large-sized mining sites in which underground obsidian nodules were dug out by means of numerous pits emerged in the Central Highlands during the Jomon Period. The systematic digging technology is characteristic of Jomon procurement activities. Although the earliest mining pit dates back to the late phase of the Incipient Jomon, the historical process with regard to the emergence of the digging technology for the mining is still ambiguous. The author believes that the mining skill was part of the digging technology that the Jomon people used for making pitfall traps in hunting fields and dwelling pits in semi-sedentary settlements.

Landscape use

The Upper Palaeolithic obsidian procurement at the sources is strongly linked to primary nodule processing and stone tool production. Either short-term intensive obsidian reduction or long-term recurrent site use specialized in stone tool production caused the formation of large-sized lithic workshops adjacent to the procuring spots. Also, there were temporary encampments in association with hunting activities at the source area, which are composed of relatively small-sized lithic concentrations that are similar to those that remained in the residential areas of the Kanto Plain. It appears that the distribution of encampment sites reflects both the mobility routes that connected the procuring spots and the approaching routes from distant residential areas to the sources. The combination of various activities closely related to the procuring spots is characteristic of the Upper Palaeolithic landscape use in the Central Highlands.

The activities at the mining sites of the Jomon people consisted of 1) mining, 2) selecting obsidian nodules, 3) primary processing (depending on the case), and 4) the carrying out of selected nodules and flaked obsidian pieces (the latter depending on the case). The hearths, the concentrations of charcoal, and Jomon pottery packed between the mining spoils were discovered at SD No. 1 (**Fig. 7: Photo 1**) and mining pit No. 01 at the Hoshikuso Pass (Anbiru et al. 2000, Otake 2011). These traces indicate that the temporary encampments existed at mining spots. In the Central Highlands, however, there are scarcely any semi-sedentary Jomon settlements in association with dwelling pits near sources above the 1,000 m zone. Accordingly, highly specialized activity for procurement of obsidian buried underground is characteristic of Jomon landscape use in the Central Highlands.

Organization and circulation system

Previous literature on obsidian circulation in the Upper Palaeolithic has demonstrated that there were three types of systems for obsidian procurement and transportation: 1) The procurement was essentially embedded in the mobility strategies of local groups (Anbiru 1991; Tamura 1992); 2) small parties dispatched to the sources by the local groups procured and transported obsidian (Shimada 2012); 3) the local group(s) near the source area supplied obsidian to other local groups. A primary form of exchange occurred at the boundaries of the regional societies (Shimada 2008). The type-1 exploitation had occurred since the early part of the Early Upper Palaeolithic, as mentioned in an earlier section, and was provably responsible for the activities at the sources related to short-term and intensive obsidian processing (e.g., TI-M). It is anticipated that the type-2 exploitation led to the creation of various temporary encampments at sources similar to those in residential areas (e.g., Oiwake). The type-3 exploitation occurred only in the Late Upper Palaeolithic. The recurrent site use and multiple-source exploitation in the source area (e.g., TI-S) resulted from the type-3 exploitation, a situation which implies the emergence of local group(s) who managed the source area.

The cost for obsidian transport in the Upper Palaeolithic circulation systems was high compared to that of the Jomon, because the obsidian circulation, including the primary form of exchange, was totally dependent on the movements of a person or a group who collected obsidian at the procuring spots. Accordingly, intensive preparation for core reduction and stone tools at the procuring spots was required to avoid the case in which low-quality obsidian unsuitable for stone tool manufacturing would be brought into residential areas far away from the source.

Specialized task groups engaged in the mining activities, including primary processing, were obviously organized in Jomon obsidian mining. The locations of the Jomon settlements and the mines were completely distinguishable from each other in the Central Highlands. A large amount of obsidian artifacts and storage features of obsidian nodules has often been found at Jomon settlements located in the zone below 1,000 m (Nagasaki 1984, Tanaka 2001). These storage features were employed since the Early Jomon, and proliferated in the Middle Jomon. These settlements are interpreted to be relay stations for obsidian circulation in a wide area. The circulation of obsidian in the Jomon was totally dependent on exchange or trade networks connecting the sources and the distant local groups (Kosugi 1995, Daikuhara 2007). The lower transport costs than those of the Upper Palaeolithic enabled the establishment of highly organized procurement activity at the source, that is, mining. The Jomon exchange networks reflect both the establishment of the local group(s) who exclusively managed the source area and controlled obsidian circulation, and the emergence of highly sophisticated social relations among the regional Jomon societies of central Japan.

Finally, there remains the most challenging issue, namely, determining by what causes obsidian mining was brought about in the Jomon Period. It is suspected that the main driving force was the amelioration of the glacial conditions and the vegetation changes in the mountain ranges above 1,500 m in the early Holocene, which developed humus and topsoil and extended the forest zone, concealing most of the obsidian nodules once exposed on ground surfaces during the glacial period. However, there is still a need to discuss this issue and collect further evidence.

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