# 9 Using Lithic Refitting to Investigate the Skill Learning Process: Lessons from Upper Paleolithic Assemblages at the Shirataki Sites in Hokkaido, Northern Japan

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**Abstract**

This paper investigates skill acquisition in the past through the analysis of refitted sets of lithic artifacts. The refitted sets belong to the late Upper Paleolithic (cal. 17–14 ka), and were obtained from the Hattoridai 2, Kamishirataki 2, and Kamishirataki 8 sites in Hokkaido, Northern Japan. Notable findings include the following. (1) Highly skilled knappers used various raw materials for blade production at the Kamishirataki 8 site. This suggests that the particular choice of lithic raw material "packages" is not always associated with different skill levels among knappers at the stage of lithic manufacture. (2) Missing blade cores ("ghost cores") as well as missing blades ("ghost blades") among the refitted sets can offer a useful signature of the knappers' skill. (3) Novice knappers carried out simple training exercises at the Hattoridai 2 site, whereas the refitted sets from the Kamishirataki 2 site suggest that experts conducted pedagogical demonstrations for the benefit of one or more novices. The main conclusion from the analyses presented in this paper is that observation and imitation, as well as some kind of instruction, played significant roles in the skill learning process among the inhabitants of these Upper Paleolithic sites.

**Keywords**

Blade reduction • Lithic refitting • Shirataki sites • Skill learning • Upper Paleolithic

## 9.1 Introduction

Previous studies of prehistoric lithic assemblages, based on either culture-historical or human-ecological perspectives, have made an implicit assumption that knappers in the past shared an identical technological tradition and competence within their own specific community. Most of these approaches employed to understand prehistoric lithic technology have been characterized by a macro-scale orientation which tends to focus on an evaluation of inter-assemblage variability (Dobres and Hoffman 1994). This has provided archaeologists with a powerful means of addressing questions associated with the reconstruction of cultural traditions and the study of resource management and land use among prehistoric hunter-gatherers. However, such approaches usually lack explicit and sustained interest in micro-scale social contexts, such as the active role of past agents in creating and manipulating the material culture (Dobres 1995).

Archaeologists still understand little about how knappers in the past actually acquired and transmitted the knowledge and know-how necessary for lithic production, although such cultural information was universally transmitted between generations. An understanding of the learning and skill transmission process should have important implications for the study of prehistoric societies, because it offers us the potential to document the child as well as the development of the craft specialists in a given society (Finlay 1997; Grimm 2000; Minar and Crown 2001). Previous studies have led to an over-simplification in the evaluation of technological

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variation at the intra-assemblage level. However, recently some methodological and theoretical discussions regarding how skill can be defined and how skill can be acquired—discussions based on diverse implications obtained from experimental and ethnoarchaeological research—have played a fundamental role in clarifying the learning and skill transmission processes in the archaeological record (e.g., Bleed 2008; Clark 2003; Eren et al. 2011; Geribàs et al. 2010; Pelegrin 1990; Shelley 1990; Stout 2002). Such research shows that archaeologists need to focus on technological variation within certain lithic assemblages in order to evaluate uneven expressions of skill within a given community.

The refitting of lithic tools and production debitage can be viewed as reflecting knapping activities carried out at a specific time in the past at the place of discovery. An analysis of the spatial patterning of the refitted sets may reveal past human behavior involved in the skill transmission process. The study of lithic refitting, paying special attention to differences in knappers' competence at lithic manufacture, may offer rich information about the skills expressed materially by past knappers, along with the operational sequences in lithic production. Where numerous pieces of artifacts, such as cores, blades or microblades, retouched tools, and debitage, have been successfully conjoined, we can directly understand how past stoneworkers operated and organized their activities, as well as which technological choices and decisions they made or did not make, from the initial acquisition of raw materials through to tool manufacture, use, and discard (Bleed 2002; Takakura 2010).

The main purpose of this paper is to explore various applications of lithic refitting in an investigation of the learning and skill transmission process in lithic production. In particular, this paper presents an attempt to assess the methodological issues regarding the evaluation of the lithic refitted pieces to prove the skill transmission process in prehistoric contexts. I approach this through a brief review of recent discussions concerning such issue and an analysis of the large quantity of lithic refitted pieces from Upper Paleolithic assemblages at the Shirataki sites in Hokkaido, Northern Japan. Because of the wealth of information that can been obtained from lithic refitting, careful analysis of these materials can deepen our understanding not only of the chrono-cultural sequence of the Upper Paleolithic period in Hokkaido from a techno-typological perspective, but also of the technological characteristics of the lithic reduction sequences in various lithic assemblages. These materials also potentially provide us with a reconstruction of knapping activities and their behavioral contexts in terms of the chaîne opératoire approach (e.g., Audouze and Valentin 2010; Pelegrin et al. 1988; Pigeot 1990; Soressi and Geneste 2011). Analyzing and comparing these lithic refitted pieces may perhaps encourage us to examine the relationship between the contexts of past knapping activities that occurred at the site and how skill was acquired and materially expressed.

The rest of this paper is organized as follows. I will first offer some of the background information necessary to consider the learning and skill transmission process in lithic production. This is followed by a brief description of the Shirataki sites. Refitted sets from the Shirataki sites are then discussed and compared, with special reference to blade reduction sequences. The implications of these commonalities and differences are discussed with particular regard to insights they may offer into technological variation at the intra-assemblage level, which is understood to reflect different technical skill levels.

## 9.2 Placing Skill in a Behavioral Context

There is a fairly broad consensus that sophisticated lithic manufacturing requires a great deal of practice and knowledge before good results can be achieved consistently (e.g., Clark 2003; Pelegrin 1990). The skills relevant to lithic production must be behaviorally acquired and developed, rather than simply learned like a series of facts. Repeated practice is essential to any systematic success in the operations involved. The durable nature of stone and the sequential character of chipped stone technology ensure that information relevant to novice knapping episodes can be preserved in lithic artefactual materials recovered from archaeological sites, thus making the skill learning process accessible to archaeological observation (e.g., Bamforth and Finlay 2008; Bleed 2008; Grimm 2000; Roux et al. 1995). The evidence gained from lithic refitting can be even more suitable for addressing such an issue. In addition, the spatial patterning of lithic refitted artifacts allows us to consider the skill learning processes that occurred at prehistoric sites. In an attempt to examine this process by analyzing the lithic refitted artifacts and their spatial patterning at a site, it is necessary to identify the outcome of activities by knappers possessing different skill levels from the analysis of lithic refitted artifacts.

Indeed, investigations carried out at some of the Magdalenian open-air sites in the Paris Basin, France, such as Étiolles, Pincevent, Marsangy, and Verberie, have produced important case studies that use refitting in attempts to identify the technical skill levels associated with flint blades and bladelet production (see Bodu et al. 1990; Janny 2010; Karlin et al. 1993; Olive 1988; Pigeot 1987, 1990, 2004, 2010 and many others). These studies have also aimed at understanding the composition of domestic units and the socio-economic organization involved in technical activities.

In Japan, pioneering work addressing the identification of technical skill levels based on the technological analysis of blade cores and microblade cores has been carried out for at least a decade (Abe 2003, 2004, 2009). In particular, at Suichouen, an Upper Paleolithic site in Western Japan, the recovery of numerous refitted sets relevant to the reduction processes of the Setouchi method have offered interesting suggestions about the composition of domestic units and the skill learning processes that occurred within them (Takahashi 2001). With the recovery of microblade assemblages related to the Yubetsu method at the Onbara 1 site in Western Japan, a difference of skills among the knappers has been discussed, based on some of refitted sets (Mitsuishi 2009). Part of the refitted sets obtained from the Shirataki sites, which I will analyze in this paper, has been assessed to prove a difference of skill among the knappers (Naoe 2003, 2007). These studies have particularly focused on some of the technological features such as the careful preparation and maintenance of the core volume as well as the appropriate restoration of errors in order to evaluate the technical skill levels among the knappers. It is apparent that an analysis of the technological features and spatial patterning of the refitted sets found at these sites has provided considerable insight into the micro-scale social context of lithic production.

Recently, there has been much discussion of the criteria upon which the determination of technical skill levels through the refitting of artifacts should be based (e.g., Bamforth and Finlay 2008; Finlay 2008; Perdaen and Noens 2011). A fundamental obstacle is that the relationship between an archaeological artifact and skill is complex and may be difficult to deal with. In an attempt to identify technical skill levels, recent approaches have often relied upon a number of qualitative value judgments such as productivity, precision, regularity, the patterned multistage of operations, and so on. These judgments draw our attention to both the result of an action and the way it is performed.

Yet what levels of consistency in production we should expect remains obscure. As demonstrated by some researchers (Audouze and Cattin 2011; Ferguson 2008; Finlay 2011; Shea 2006; Sternke 2011; Stout 2002), skill and its material expression depend to a certain degree on the lithic raw materials used and their availability. Needless to say, the contexts of knapping activities, technological needs, and the availability of raw materials might significantly affect the operational sequences employed by knappers (Takakura 2010). Skill and its material expression in the lithic manufacturing process also encompass a broad range of situations and micro-scale contexts. These factors would have affected not only whether unskilled knappers were permitted to experiment, sometimes tied with play (Ferguson 2008; Högberg 2008), but also to what varying degree the knapping activities of highly skilled knappers might have been present. Ethnographic data on contemporary stone adze production presented by Stout (2002) indicate that the variation in adze blades produced by skilled knappers is influenced by access to raw material. It appears necessary then for us to know more about the goal of production and differences in access to raw materials. Reconsidering environmental constraints and the context of human behavior is both interesting and challenging for an archaeological understanding of the skill learning process.

The lithic refitted sets derived from the Magdalenian assemblages in the Paris Basin show that the raw materials used in the production of blades and bladelets varied from large blocks or slabs measuring up to 70 cm long to small nodules of approximately 10 cm long. It seems that the variability of the morphological features in the raw materials originates in the different sources of flint within the Paris Basin (Audouze and Cattin 2011; Valentin et al. 2002). Several researchers (Abe 2004; Bodu et al. 1990; Grimm 2000; Karlin et al. 1993; Pigeot 1990) have argued that the selection of raw material itself generally depended on differences in the technical skill levels among knappers. A highly skilled knapper's ability is reflected from the beginning of the technological process, in that he tended to choose large blocks or slabs of fine quality as the raw material for blade knapping. Since searching for the sources of both large and fine-quality raw materials probably required a great deal of knowledge of the distribution of resources within the natural landscape, an apprentice knapper would not have had the same access to fine-quality raw materials, so tended to select small and low-quality nodules that ubiquitously distributed within the natural landscape. It is generally accepted that the correlation of raw material types with technological characteristics in Magdalenian assemblages, or in other assemblages, can be interpreted as representing differences in the competence of the knappers.

There is, however, no reason to suppose that the technical activities performed by Paleolithic knappers were invariable, regardless of what types of raw materials were used. It is worth questioning how technical skill levels were expressed materially if and when highly skilled knappers in the past were confronted with the need to exploit and use the various lithic raw materials available. Unfortunately, the important question of how knappers in the past dealt with the variety of raw materials, especially the variety of size and form, has been given little consideration. It is apparent that the relationship between the variety of available raw material and the criteria we use to identify technical skill levels should be further explored by analyzing suitable collections. Comparing refitted sets that show the original form of raw materials "packages", such as pebbles or debris within and/or between lithic assemblages, may be useful for resolving these issues.

## 9.3 The Shirataki Sites

The Shirataki sites are situated near Engaru, Eastern Hokkaido, Japan (Fig. 9.1). The sites lie around the upper stream of the Yubetsu River Basin, covering several square

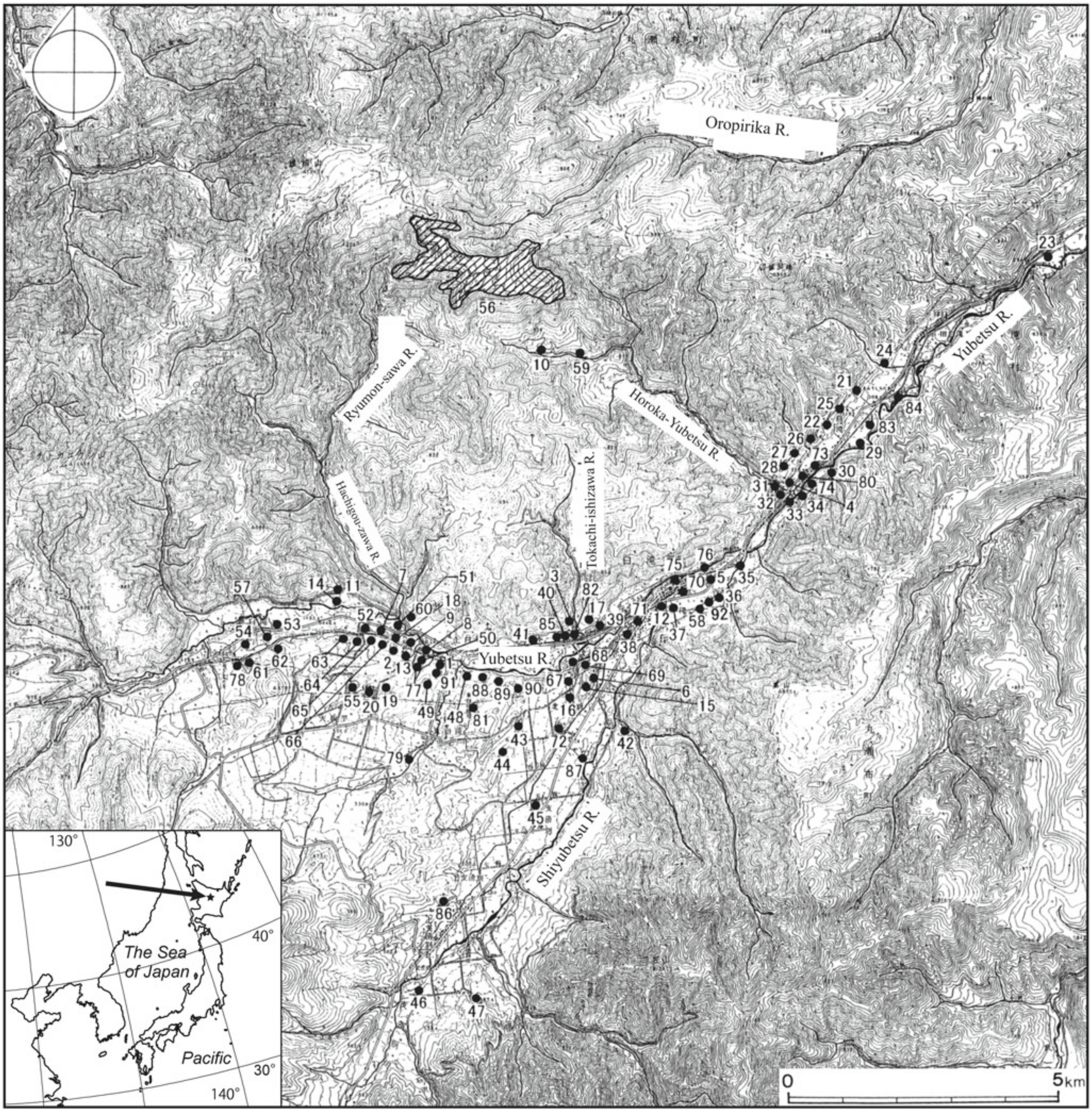


**Fig. 9.1** Locations of the Paleolithic sites in Shirataki (modified after Suzuki and Naoe 2006). Hattoridai 2 site: 13, Kamishirataki 8 site: 91, Kamishirataki 2 site: 48, Akaishi-yama: 56

kilometers. Most of the Paleolithic sites known to us in Shirataki are topographically located along the margins of river terraces and hills, while a few sites have been identified in inaccessible mountain locations.

The sites identified around the upper stream of the Yubetsu River Basin have been repeatedly excavated by archaeologists since the 1950s. From a techno-typological point of view, most of the lithic assemblages obtained from the various sites in Shirataki belong to the Upper Paleolithic, and radiocarbon dating from some of the sites further supports this inference. Importantly, the Shirataki sites are located near a huge outcrop of obsidian that is of good quality, with few interior inclusions. The Upper Paleolithic inhabitants of the sites procured lithic raw materials from these local obsidian sources, and a large amount of lithic production was carried out at the sites. As Ferguson (2008) has suggested, it is probable that the closely related factors of raw material value and access were influential in determining how skill learning processes occurred in many contexts of prehistoric lithic production. In a situation where raw material is relatively abundant and of low value, a novice knapper may be permitted a degree of trial and error, either on his own or under the supervision of a skilled knapper. This matches the context of the Shirataki sites, where obsidian pebbles and debris favored for use as lithic raw material were abundant and could be easily acquired. Accordingly, it seems reasonable to expect that novice knapping activities could have occurred at these sites.

The excavations of the sites have yielded numerous stone artifacts suitable for describing and defining lithic reduction sequences, such as the Yubetsu method (Yoshizaki 1961), and they have allowed us to undertake detailed technological analyses of various microblade reduction sequences (e.g., Kimura 1992; Nakazawa et al. 2005). From a techno-typological perspective, studies of the Shirataki sites have focused on methods of tool manufacture used as time markers. Additionally, the materials from these sites have encouraged archaeologists to discuss an issue of truly international scope: the appearance and dispersal of pressure microblade production, which was regarded as a technical breakthrough of that time (Inizan 2012; Inizan et al. 1992; Takakura 2012).

It is necessary to note that most of the investigations at Shirataki before the 1990s involved relatively small areas and short-term excavations. However, since 1995 the Hokkaido Archaeological Operations Center has conducted lengthy investigations at Shirataki which are quite different from the previous excavations. The Center has extensively excavated 23 archaeological sites at Shirataki because of the construction of an expressway. The total area of excavation covers approximately 123,000 $m^2$ (Naoe 2012) and has resulted in the recovery of various lithic assemblages, including from the early to the late Upper Paleolithic. Large quantities of obsidian artifacts, mostly debitage, recovered from various findspots show that the sites were frequently occupied by prehistoric humans during the Upper Paleolithic and were related to the procurement and working of obsidian raw materials. The generally accepted view of the Upper Paleolithic hunter-gatherers in Hokkaido, Northern Japan, is that they were residentially mobile foragers wandering over a wide geographic area to exploit scattered resources in a cold and dry environment. The facts often cited in support of this are that the obsidian artifacts originating from the Shirataki sources are widely distributed in Hokkaido, and that lithic assemblages mainly comprised of these obsidian artifacts have been recovered from various other areas in Hokkaido, as far as 200–300 km from Shirataki (Kimura 1992; Nakazawa et al. 2005). Many analyses regarding the obsidian source provenance validate this inference.

The recent investigations have managed to fully document the spatial distributions of the stone artifacts in the sites, and consistently refit stone artifacts in the various lithic assemblages (e.g., Naganuma et al. 2000; Naoe 2012). Both matters had not been fully explored until then. The majority of the lithic assemblages from the Shirataki sites are made up of locally available obsidian, which often exhibits considerable macroscopic variation from one piece to another, and therefore helps in the refitting of a great deal of manufacturing debris and stone tools.

It is important that the refitting of artifacts leads to an assessment of the integrity of context and the degree of movement of each artifact, and on occasion enables an assessment of an approximate span of time that the assemblage represents. Moreover, refitting studies assist archaeologists in developing detailed technological analyses of lithic reduction sequences, especially of what raw materials were selected and how methods and techniques were followed by knappers in the past. Undoubtedly, new discoveries have been made at the Shirataki sites that not only alter our techno-typological understanding of Upper Paleolithic assemblages in Hokkaido, but also expand the potential of lithic refitting for the evaluation of prehistoric human behavior (e.g., Naoe 2003; Suzuki 2007; Takakura 2010).

The archaeological records at Shirataki, like those of other Paleolithic sites in Hokkaido (Nakazawa et al. 2005), have been subject to disturbance by non-human forces. Small scale reworking, perhaps due to solifluction, is common throughout the Upper Paleolithic sites at Shirataki. This leads to the downslope movement of stone artifacts on the exposed surfaces, and this process would have altered the distributions of the archaeological materials to some extent. Nevertheless, it has not crucially impacted the integrity of the context on a scale requiring discussion in this paper, because the patterning of the refitted stone artifacts, especially manufacturing debitage, generally follows the spatial clustering at the sites.

The lithic refitted pieces obtained from the Shirataki sites are unique in the Upper Paleolithic record in Japan in three respects. First, numerous refitted pieces have been recognized from each of the assemblages, offering a wealth of technological information on the production of blades, microblades, bifaces, and boat-shaped tools. This allows us to compare refitted pieces within lithic assemblages that are supposed to represent an identical cultural tradition. The procedure for such comparisons may prove a useful way of considering unevenly expressed skill levels within certain assemblages, in order to explain the skill learning process among knappers in the past.

Second, many obsidian refitted artifacts have been recognized, conjoined with a quantity of stone tools and debitage, and some of these have been reconstructed nearly to the level of the original nodule or slab of raw material. These materials can contribute to an understanding of the morphological features of cobble and lithic debris originally selected for use as raw material by the knappers. This is important because we need a better grasp of the relationship between raw materials and certain attributes regarded as skill signatures in previous studies.

Third, we can assess the spatial distributions of refitted lithic artifacts within the sites, although these have been, to some extent, modified by natural transformation processes such as solifluction. Analyzing these distributions is critical to answering questions about skill learning processes, as it highlights how the distribution of analyzed refitted lithic artifacts relates to prehistoric human behavior at the sites.

## 9.4 Analyzing Refitted Sets from the Shirataki Sites

### 9.4.1 Criteria for Identification of Technical Skill Levels

I focus here on the skill learning processes reflected in refitted sets concerned with blade reduction. This study follows Andrews (2003), Audouze and Cattin (2011), Bodu et al. (1990), Clark (2003), Johansen and Stapert (2008), Karlin et al.(1993), Naoe (2003), Pigeot (1987, 1990), and Shelley (1990) in considering some of the technological characteristics observed in the refitted sets as a key to understanding technical skill levels. The most well-known studies concerned with such an approach, as mentioned above, have been carried out in the Magdalenian open-air sites in the Paris Basin. A technological analysis of flint knapping at these sites shows that, to a certain extent, three levels of skill—expert knappers, advanced learners, and beginners—can be recognized in the refitted flint evidence. At Étiolles U5 in particular, up to six or seven levels of skill were distinguished (Olive 1988; Pigeot 1987, 1990). Such research also revealed that the unskilled knappers tended to work in locations that were peripheral to the hearth-centered activity zones, whereas the skilled knappers tended to conduct their knapping activities around the hearths.

These studies have also highlighted some of the qualitative evidence indicative of the activities of highly skilled knappers, including high productivity of blades, regularity of the form of the blades, careful preparation and maintenance of the core volume especially when rejuvenating the platform and ridge, patterned multistage reduction sequences, appropriate restoration of errors such as hinge fracture terminations (e.g., Naoe 2003; Shelley 1990), and precise application of force. Other evidence is characteristic of the activities of novice knappers, including low productivity of blades, irregularity of the form of the blades, failure to rejuvenate, wasteful and ineffectual use of raw materials, and misapplication of force, especially resulting in face battering and stacked steps (Johansen and Stapert 2008; Shelley 1990). Of course, we cannot necessarily assume that such features in the particular refitted sets can always be observed systematically. A dichotomization of skill among prehistoric knappers is obviously too simplistic to apply to the varied archaeological evidence. At the least, we must also consider a medium level of skill, for example, the advanced learner with a modest productivity (Johansen and Stapert 2008).

In addition, of particular concern in this paper is the behavioral context of knapping activities and the technological needs relevant to evaluating skill learning processes. Therefore, I attempt to assess not only the technological characteristics that have been generally interpreted as skill signatures in previous approaches, but also the presence/absence of blade cores, as well as the degree of absence of blades, among the refitted sets. The former is a matter of whether the blade cores we expect to be included in the refitted sets are recovered from the site or not. The latter refers to a comparison between the estimated number of produced blades and the estimated number of missing blades in the refitted sets. Because recent excavations at the Shirataki sites have been conducted extensively, and refitting of the recovered stone tools and debitage was careful and patient, the presence or absence of blades and blade cores in the refitted sets can provide useful and reliable information for evaluating the behavioral context of knapping activities (e.g., Suzuki 2007). These phenomena are related to the notion of the "ghost", a term coined by Morrow (1996) to refer to how artifacts are taken away from a site while the manufacturing debitage remains and can be refitted. Morrow stressed that this was correlated to the site occupation span.

The approach presented here is based on the combination of two indicators, namely the presence/absence of blade cores and the degree of absence of blades, which may be connected with the levels of technical skill the prehistoric knappers had, and the behavioral contexts in which knapping occurred. Because the Upper Paleolithic hunter-gatherers in Hokkaido were residentially mobile foragers who adapted to a cold and dry environment (e.g., Kimura 1992; Nakazawa et al. 2005; Takakura 2012), they may have needed to reduce the transportation burden of their tool kits and blanks in order to reduce the costs of residential moves. To supplement the kits and blanks systematically, mobile hunter-gatherers of the Upper Paleolithic repeatedly visited Shirataki. They likely acquired and processed obsidian raw materials for the production of portable blanks and stone tools. Needless to say, not all of the blanks and tools produced at Shirataki were necessarily taken away from the Shirataki sites. Generally speaking, well-made blade cores and blades were exported from the Shirataki sites with expectation of their further use as blanks or tools. These artifacts were more likely to be products of expert knappers. In contrast, the majority of the products knapped by novices were left where they were struck, supporting the hypothesis that these scatters represent simple training exercises (Bodu et al. 1990).

Of course, we clearly need to consider whether this prediction is applicable or not. Blade cores were likely abandoned at

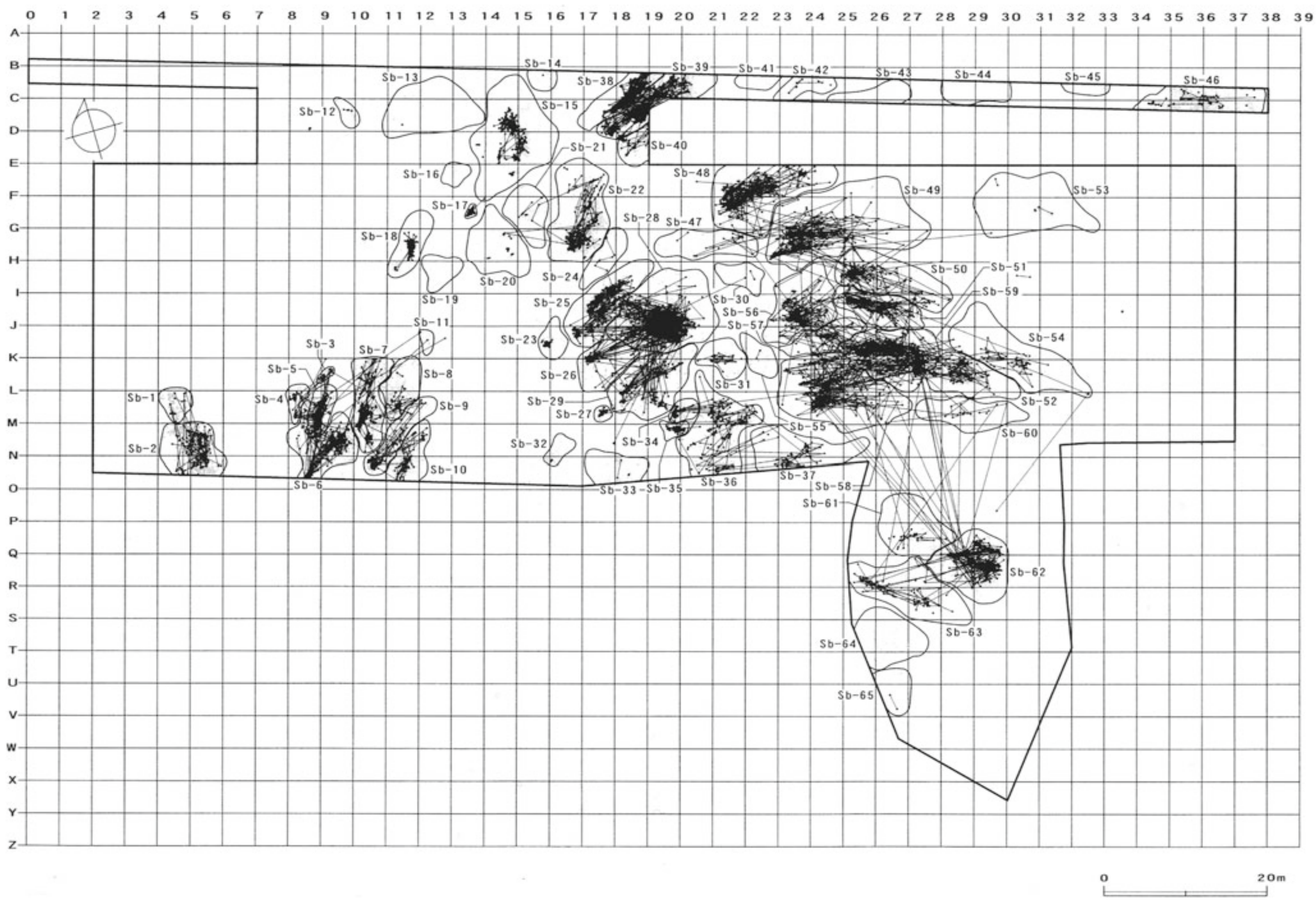


**Fig. 9.2** Distributions of stone artifacts in the Hattoridai 2 site (Naoe 2007). Note the connecting lines among the small dots show that they are refitted

the site when significant accidental flaking occurred (e.g., due to inferior inclusions or joint surfaces in the obsidian pieces) and such an error would have simply stopped the operational sequences. However, in other cases, they may have been abandoned for economic reasons: work stopped when the core was found to be too small to create the final product (e.g., Karlin and Julien 1994). Without knowing more details about the results of flaking that might have led to abandonment, we cannot automatically regard the presence of blade cores as an indicator of prehistoric knappers' skill level. If we find an inconsistency between the presence/absence of blades, as well as of blade cores, and the technical skill level recognized through the technological skill signatures, we should look for a different interpretation of the knappers' behavior.

Below, I present data documenting the skill levels and learning processes obtained from three Shirataki sites: the Hattoridai 2 site, the Kamishirataki 8 site, and the Kamishirataki 2 site.

### 9.4.2 The Hattoridai 2 Site

The Hattoridai 2 site was excavated from 1998 to 2000 (Naoe 2007). The excavations revealed the presence of Upper Paleolithic cultural strata lying 20 to 50 cm below the present surface. The number of artifacts recovered from the site is 798,648, and all materials represent the late Upper Paleolithic period from a techno-typological point of view. The total area of excavation covers 6,691 $m^2$. A total of 53 spatially discrete artifact concentrations have been identified (Fig. 9.2): these have been grouped into 28 units according to similarity in lithic technological characteristics observed in the recovered artifacts and the intra-site spatial patterning of refitted sets. Each of the units may be understood to represent a distinct cultural component. Here, I focus on the lithic assemblages obtained from the unit concentration Sb-23–31 because there is rich information to be derived from the refitting of stone artifacts. While the spatial distribution of this concentration may, to some extent, be modified by post-depositional agents such as solifluction, the spatial patterning of the refitted sets shows that this concentration is useful for understanding the processes in knapping activities.

The assemblage from concentration Sb-23–31 consists of side-scrapers, end-scrapers, gravers, boat-shaped tools, blades, blade cores, flakes, chips, and various types of bifaces. Blades are used as blanks for these flake tools. All of the flake tools are made of obsidian which mostly came from

**Table 9.1** Refitted sets from concentration Sb-23–31 at the Hattoridai 2 site

| No. | Raw material | Size (cm) | Weight (g) | Blade core | Number of recovered blades | Total number of refitted pieces |
|---|---|---|---|---|---|---|
| 153 | Angular gravel | 31×17×27 | 3,745 | Absent | 12 | 272 |
| 130 | Sun-angular gravel | 27×17×11 | 1,451 | Absent | 15 | 151 |
| 129 | Sun-angular gravel | 22×16×10 | 1,847 | Absent | 2 | 45 |
| 128 | Round gravel | 26×16×23 | 6,676 | Present | 5 | 98 |
| 203 | Round gravel | 30×11×19 | 6,595 | Present | 0 | 15 |

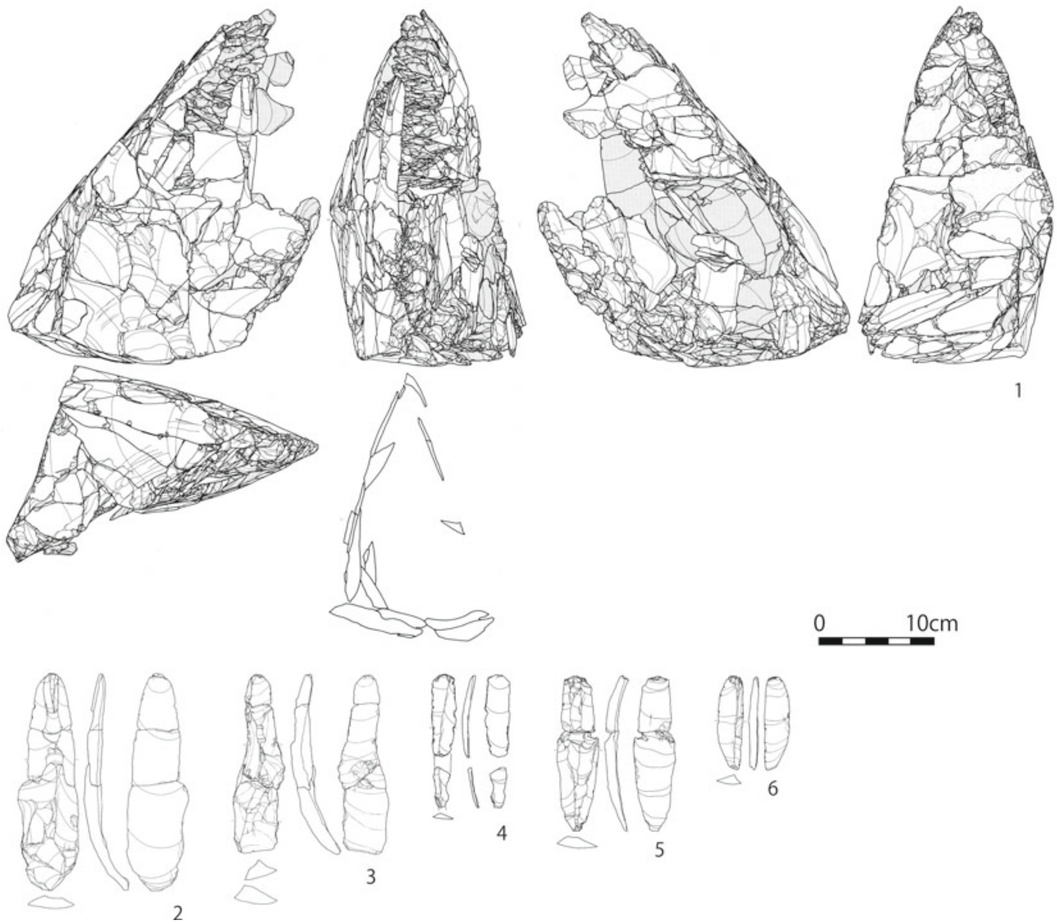


**Fig. 9.3** Refitted set No. 153 from the Hattoridai 2 site (1) (Naoe 2007). *1*: refitted set, *2–6*: blades included in the refitted set No. 153

Shirataki. The assemblage from concentration Sb-23–31, consisting of co-occurring sets of identical morphological and technological traits, indicates little reason to suspect mixing with other assemblages. Persistent refitting efforts among this assemblage provide several refitted sets that can describe the detailed processes of blade and bifacial reduction. In addition, the roundness of the natural cortex observed on the dorsal surface of lithic artifacts demonstrates that angular, sub-angular, and rounded obsidian cobbles were used to produce the blades. The assemblage is therefore suitable for elucidating the relationship between the morphological features of lithic raw material "packages" and the technological features of reduction sequences.

In this assemblage, the lithic refitted artifacts derive from both bifacial and blade reduction. Twelve of the refitted sets represent bifacial reduction, conjoining with many flakes. The bifacial reduction sequences from concentration Sb-28 were distinctively executed. In contrast, five of the refitted sets display comprehensive blade reduction sequences, conjoining with blades, blade cores, and flakes. The refitted sets related to blade reduction were mostly recovered from concentrations Sb-25, 26, and 28.

A difference in the morphological features of raw materials used for blade reduction can be recognized within the refitted sets. Angular and sub-angular obsidian cobbles were used as raw material in refitted sets No. 153, 130, and 129, whereas rounded cobbles were used in refitted sets No. 128 and 203. Table 9.1 shows a description of these refitted sets.

From a comparison of several technological features related to skill signatures, the refitted sets No. 153 (Fig. 9.3)

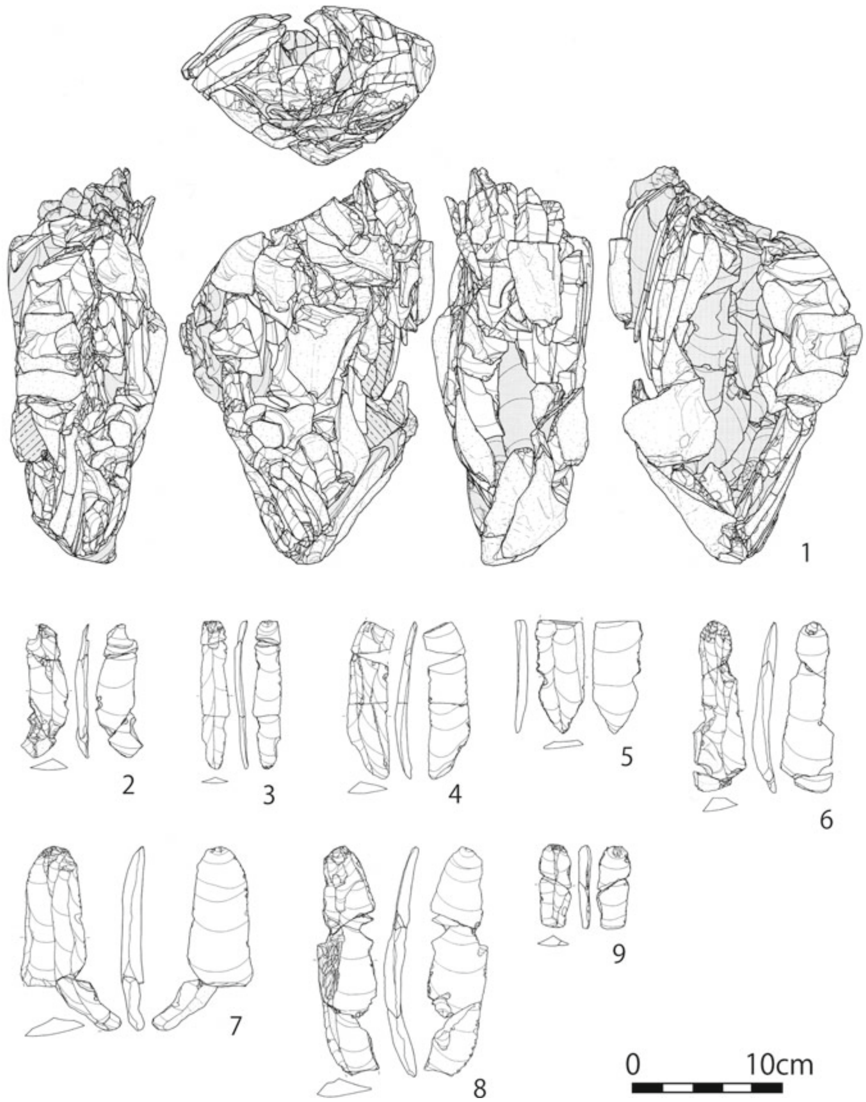


**Fig. 9.4** Refitted set No. 130 from the Hattoridai 2 site (2) (Naoe 2007). *1*: refitted set, *2–8*: blades included in the refitted set No. 130

and 130 (Fig. 9.4) can be interpreted as having been produced by a skilled knapper. Both cases show that the prepared blanks of cores were imported to the site and used for the blade production. The cores were prepared and rejuvenated carefully by cresting over the full length of the production face and faceting the striking platform, and thus the proper angle between the striking platform and the production face was maintained. Thin and side-paralleled blades were subsequently produced from the production face. Few misapplications of force can be seen in either of the refitted sets. Neither of the blade cores in both refitted sets was recovered from this site. Additionally, there are very few blades associated with these refitted sets. In general, concentration Sb-25 (Fig. 9.5), from which these two refitted sets came, is characterized by a scarcity of blade cores and blades.

In contrast, the refitted sets No. 128 (Fig. 9.6) and 203 (Fig. 9.7) can be interpreted as resulting from a knapper with a low level of technical skill, such as a novice knapper. The imported core blanks were less prepared in comparison with those in the expert concentrations. Bulbs of percussion observed on these refitted sets tend to be more strongly marked. Flaking resulted in thick remnants with hinge or step terminations, because of misapplications of force. In addition, the knappers of these materials failed to produce and maintain either the proper platform angle or the effective production face for the systematical blade production. The reduction processes progressed unsystematically and irregular blades were produced, with an overall low level of productivity. In these two cases, almost all of the products, including cores, blades, and flakes, are

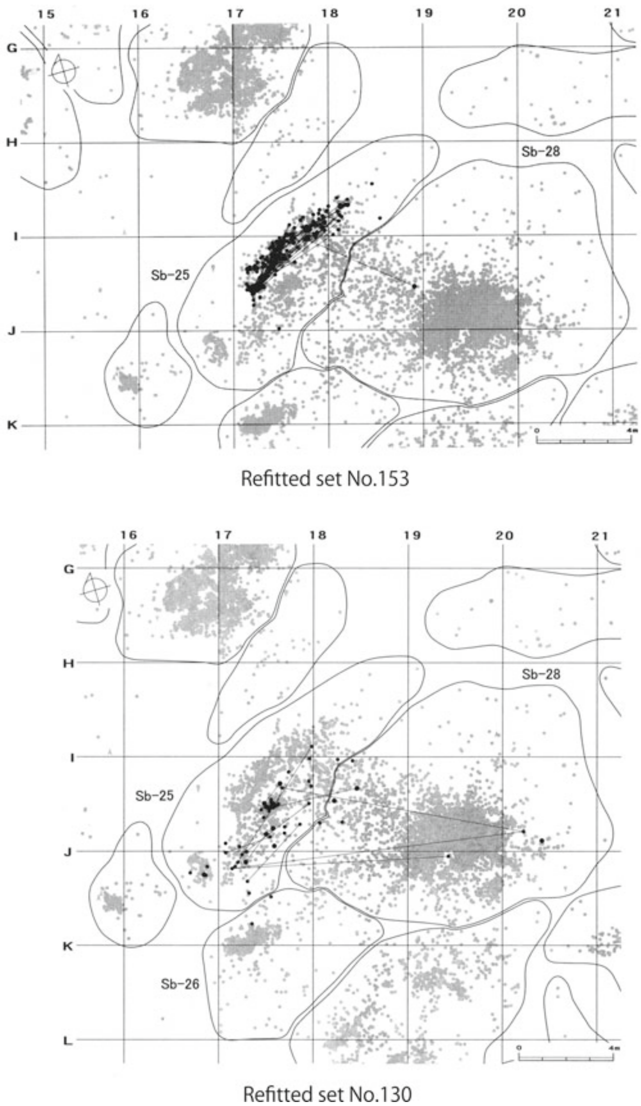


**Fig. 9.5** Distributions of the refitted sets No. 153 and 130 in the Hattoridai 2 site (Naoe 2007). Note: all artifacts are represented by *light black dots*. The *darker black dots* indicate that they were likely originated from an identical analytical core unit, identified based on the color, texture and inclusion. The *connected lines* among the *darker dots* show that they refit together

refitted and were recovered from concentrations Sb-26 and 28 (Fig. 9.8).

Some, but not all, technical elements relevant to the identification of a skilled knapper can be partially observed in the refitted case No. 129 (Fig. 9.9), which was recovered from concentration Sb-28 (Fig. 9.10). The blade core that appear to have been produced from this material was exported from the site. Therefore, No. 129 can be identified as the product of a knapper with medium-level competence, such as an advanced learner.

Comparison of the refitted sets indicates a strong similarity between archaeological skill signatures and the presence/absence of blade cores and blades. In this case, distinguishing whether blade cores and blades are present in the refitted artifacts may provide fruitful insights into the important characteristics of technical skill levels for producers of Paleolithic artifacts. Moreover, a comparison of the refitted artifacts reveals that different skill levels among the knappers are associated with the selection of raw materials: whereas the skilled knappers seem to have used angular and sub-angular obsidian cobbles as starting points for blade production, the less skilled knappers used rounded obsidian cobbles. In the case of this assemblage, there is no difference in size between the angular and rounded cobbles used for blade production. Consequently, based on the various information presented above, we can understand that the skill of prehistoric knappers in this concentration was involved in the selection of the form of raw materials, even when the technological ends were the same.

It is noteworthy that the distributions of refitted artifacts made by the skilled knappers and novice knappers are spatially distinct in this assemblage. This is valuable patterning because it can give clues to the relationships between multiple knappers with different levels of skill. In spite of limited data showing that knapping activities in this assemblage were conducted simultaneously, a distinction in the spatial patterning implies that the activity zones of the skilled knappers and novice knappers were differentiated based on well-defined spatial rules, and that such rules might therefore have been recognized by both types of knappers. It is difficult to infer from this that the experts and the beginners conducted their knapping activities at the same spot. Probably both paid attention to the other's knapping activities, either explicitly or implicitly. This would have provided favorable conditions for observational learning of knapping operations and skills. Thus, the novice knappers would have been encouraged to learn on their own, through experimental knapping activities as training exercises, but sometimes tied with observation of the skilled knappers.

This patterning is nevertheless different from that of the Paris Basin, where the best places around the hearth were reserved for skilled knappers and the apprentices were kept outside the domestic space (Audouze and Cattin 2011; Pigeot 1990). The case of the Hattoridai 2 site at least suggests that the relationship between skilled knappers and novice knappers was not spatially hierarchical.

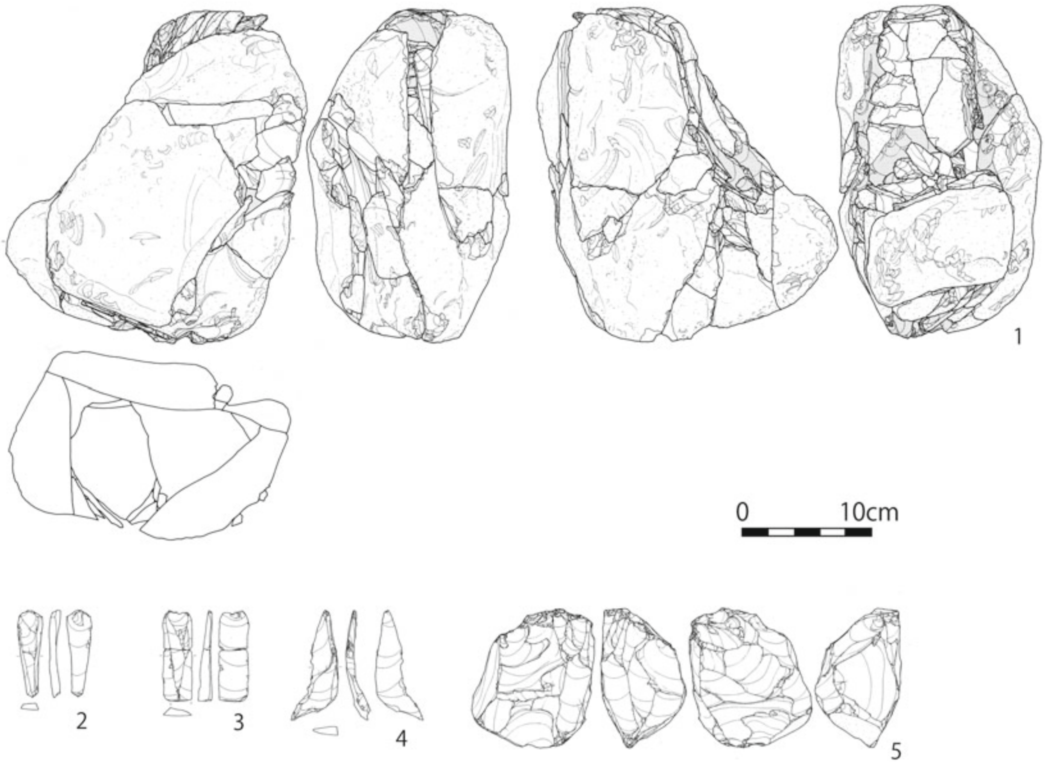


**Fig. 9.6** Refitted set No. 128 from the Hattoridai 2 site (4) (Naoe 2007). *1*: refitted set, *2–4*: blades included in the refitted set No. 128, *5*: core included in the refitted set No. 128

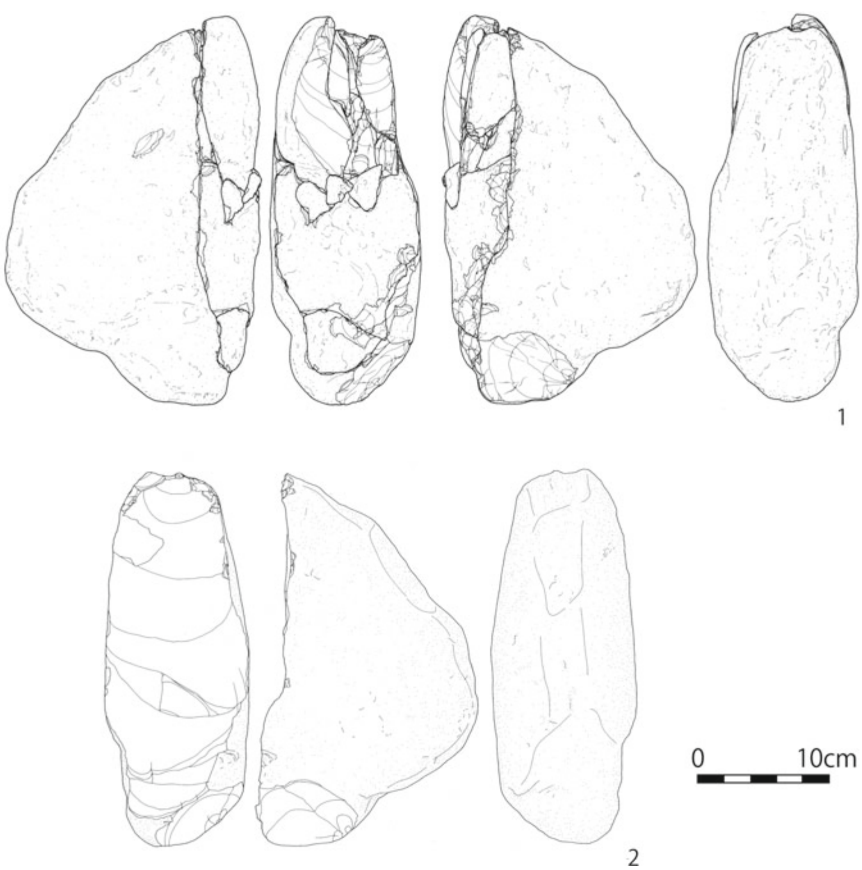


**Fig. 9.7** Refitted set No. 203 from the Hattoridai 2 site (5) (Naoe 2007). *1*: refitted set, *2*: core included in the refitted set No. 203

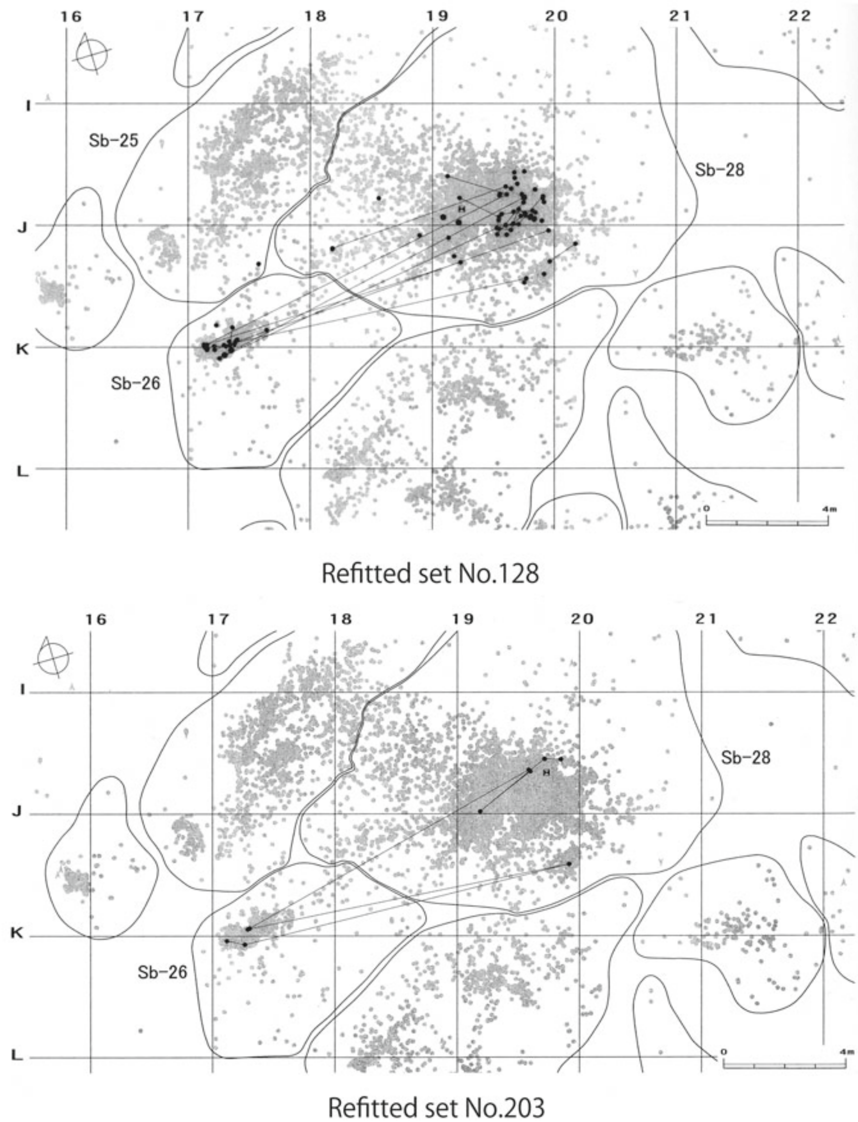


**Fig. 9.8** Distributions of the refitted sets No. 128 and 203 in the Hattoridai 2 site (Naoe 2007). Note: all artifacts are represented by *light black dots*. The *darker black dots* indicate that they were likely originated from an identical analytical core unit, identified based on the color, texture and inclusion. The *connected lines* among the *darker dots* show that they refit together

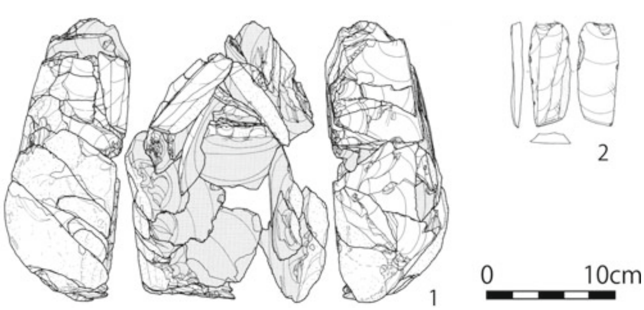


**Fig. 9.9** Refitted set No. 129 from the Hattoridai 2 site (Naoe 2007). *1*: refitted set, *2*: blade included in the refitted set No. 129

### 9.4.3 The Kamishirataki 8 Site

The Kamishirataki 8 site was excavated between 1995 and 2000 (Suzuki and Naoe 2006). The artifacts recovered number 1,354,567, and these appear to be multiple components from the early Upper Paleolithic to the late Upper Paleolithic, both from techno-typological evidence and from some available radiocarbon dates. This demonstrates that the site was repeatedly occupied during the Upper Paleolithic period. The total area of excavation covers 17,849 m$^2$, and 111 artifact concentrations have been identified, based on the spatial distribution of the artifacts and their refitting patterns.

Here, I focus on the lithic assemblage from concentration Sb-90 as it contained several refitted artifacts related to blade production, providing us with a wealth of information on blade reduction sequences as well as on the knappers' technical skill levels. Concentration Sb-90 is spatially discrete from other concentrations. This concentration may be understood to represent a distinct cultural component, because the distribution of the refitted artifacts is limited within this concentration. The assemblage also shows several major technological features, suggesting little mixing with other assemblages.

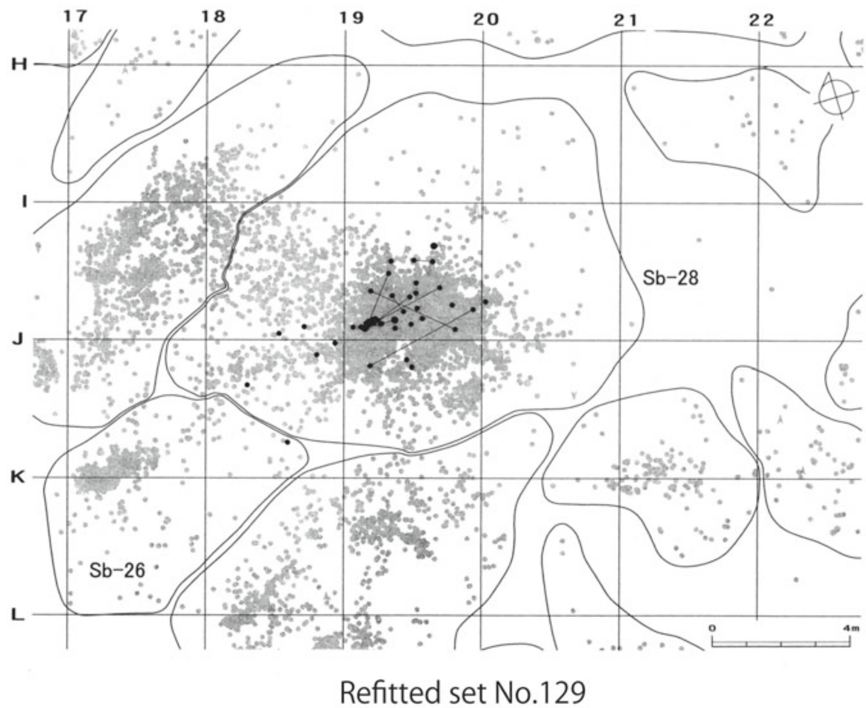


**Fig. 9.10** Distributions of the refitted set No. 129 in the Hattoridai 2 site (3) (Naoe 2007). Note: all artifacts are represented by *light black dots*. The *darker black dots* indicate that they were likely originated from an identical analytical core unit, identified based on the color, texture and inclusion. The *connected lines* among the *darker dots* show that they refit together

The assemblage from concentration Sb-90 contains an abundance of chipped stone manufacturing debris and also contains side-scrapers, end-scrapers, gravers, boat-shaped tools, blades, blade cores, cores, and microblade cores. With only a few exceptions, these are made of obsidian available at Shirataki. The Oshorokko type of microblade core (Nakazawa et al. 2005; Takakura 2012) can be recognized in this assemblage. A techno-typological comparison reveals that this assemblage belongs to the late Upper Paleolithic (Suzuki and Naoe 2006). Unfortunately, no chronometric dates have been obtained to give a reliable chronological position for this assemblage.

Large numbers of flakes, blades, and blade cores from concentration Sb-90 are successfully conjoined (Figs. 9.11 and 9.12). These show that the cobbles used in blade reduction sequences are variable, particularly in relation to form, including angular, sub-angular, and rounded forms. These cobbles may have been acquired near the site. Here, I attempt to examine eight refitted sets relevant to blade reduction, reconstructed of nearly original raw material forms, and distributed within lithic concentration Sb-90. The maximum length of the angular and sub-angular cobbles used as raw materials is slightly larger than that of the rounded cobbles. Angular and sub-angular cobbles were used in refitted sets No. 693 (Fig. 9.11: 1), 690 (Fig. 9.11: 2), 688 (Fig. 9.11: 3), and 704 (Fig. 9.11: 4), whereas rounded cobbles were used in refitted sets No. 691 (Fig. 9.12: 1), 699 (Fig. 9.12: 2), 700 (Fig. 9.12: 3), and 689 (Fig. 9.12: 4). Descriptions of these raw materials are summarized in Table 9.2.

Careful preparation, as well as repeated rejuvenations of the striking platforms and the ridges of blade cores, can be recognized in all of the refitted sets. Blade removal is unidirectional with an adapted oblong volume, with rubbing on the pecked platform, presumably with the aid of abrasives. Slender and regular blades were frequently detached (Fig. 9.13). Although the morphological features of the obsidian cobbles vary among these refitted sets, the technological characteristics observed in the blade reduction process and its products are surprisingly similar. Also, there are few differences in the technological evidence of skill signatures among these refitted sets. Consequently, it is difficult to identify any differences in the technical skill level of the knappers, in spite of the variability that can be seen in the morphological features of the raw materials. This evidence suggests that the knappers involved in the formation of this assemblage at the Kamishirataki 8 site had equivalent skills in blade production. They used various forms of obsidian cobbles as raw materials to remove the blades, in contrast to the situation at the Hattoridai 2 site.

Blade cores are present in all these refitted sets except No. 693 and 689 (Fig. 9.13). Conversely, the vast majority of blades that appear to have been detached were exported from the site. These are the "ghosts" in this assemblage. Therefore, there is an inconsistency between blade cores and blades. Interestingly, unusual flaking accidents, such as hinge fracture scars and other irregularities, usually occurred just before abandonment, especially conjoined with the blade cores (Suzuki and Naoe 2006). Such accidental flaking might have

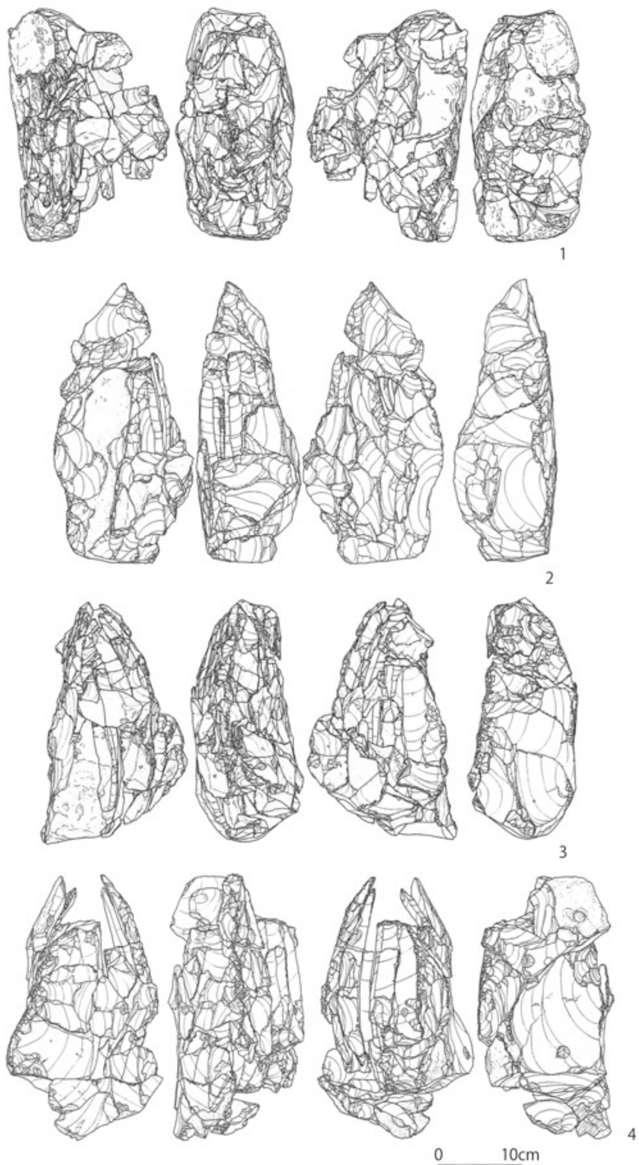


**Fig. 9.11** Refitted sets from the Kamishirataki 8 site (1) (Suzuki and Naoe 2006). *1*: No. 693, *2*: No. 690, *3*: No. 688, *4*: No. 704

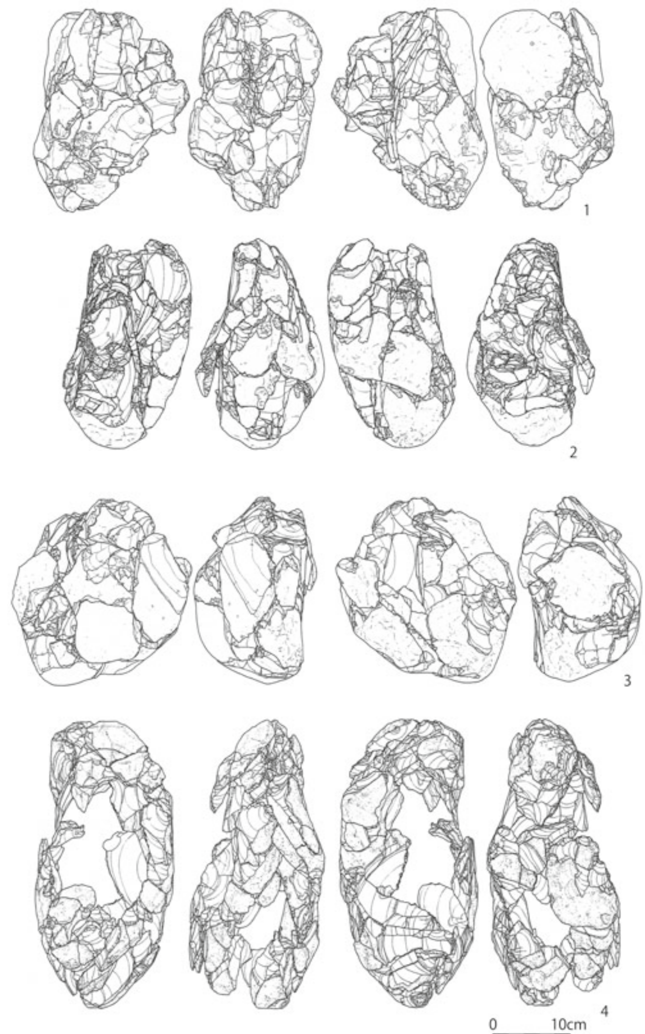


**Fig. 9.12** Refitted sets from the Kamishirataki 8 site (2) (Suzuki and Naoe 2006). *1*: No. 691, *2*: No. 699, *3*: No. 700, *4*: No. 689

**Table 9.2** Refitted sets from concentration Sb-90 at the Kamishirataki 8 site

| No. | Raw material | Size (cm) | Weight (g) | Blade core | Number of recovered blades | Total number of refitted pieces |
|---|---|---|---|---|---|---|
| 693 | Sub-angular gravel | 29×19×15 | 2,995 | Absent | 9 | 176 |
| 690 | Angular gravel | 35×17×13 | 5,342 | Present | 5 | 36 |
| 688 | Angular gravel | 30×17×13 | 4,181 | Present | 12 | 78 |
| 704 | Sub-angular gravel | 33×19×17 | 5,846 | Present | 4 | 33 |
| 691 | Round gravel | 27×19×16 | 5,486 | Present | 4 | 59 |
| 699 | Round gravel | 28×17×15 | 4,795 | Present | 7 | 89 |
| 700 | Round gravel | 26×22×16 | 5,916 | Present | 2 | 40 |
| 689 | Round gravel | 27×19×16 | 3,266 | Absent | 11 | 120 |

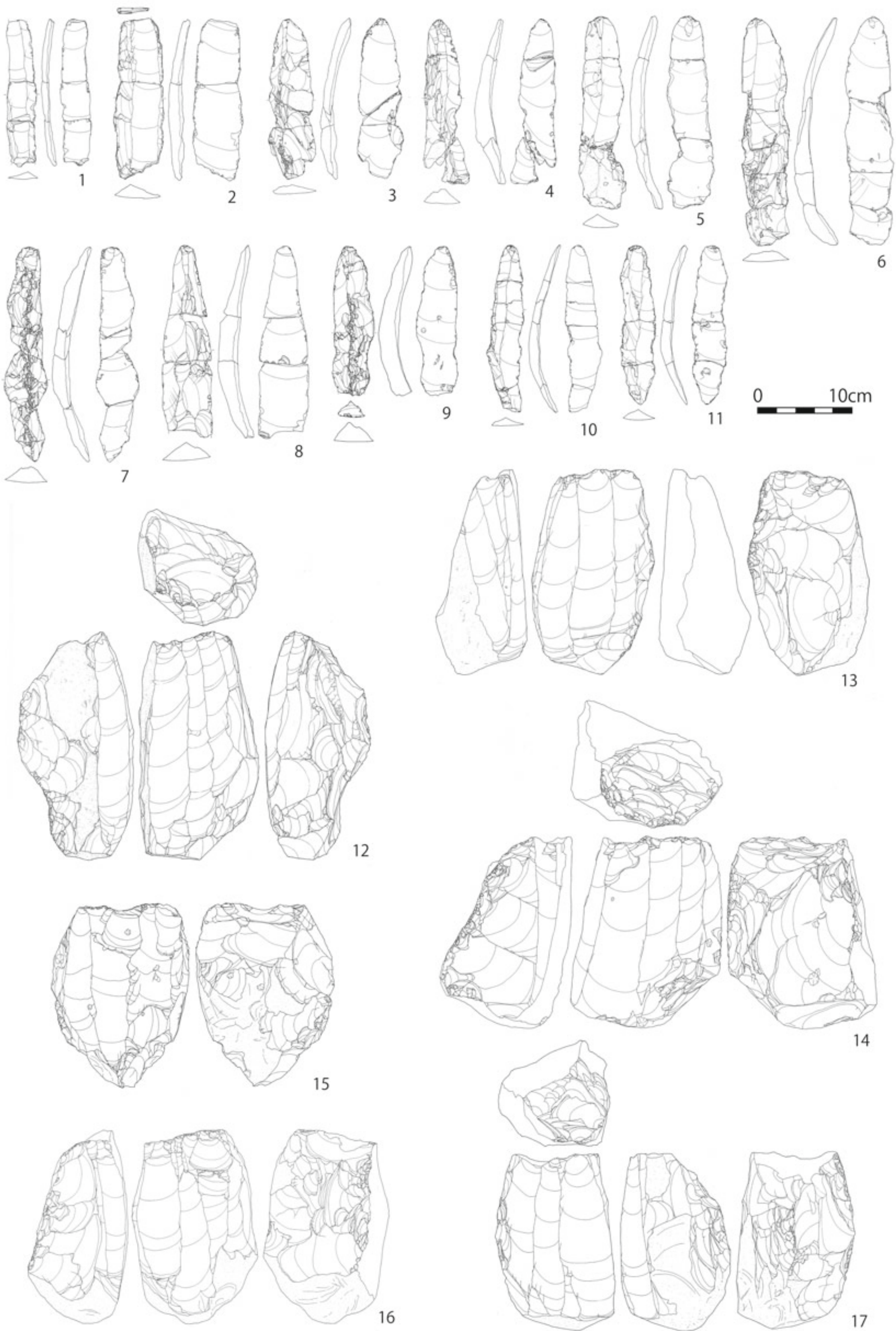


**Fig. 9.13** Blades and Blade cores from the Kamishiratakí 8 site (Suzuki and Naoe 2006). *1–2*: blades (No. 690), *3–6*: blades (No. 688), *7–8*: blades (No. 704), *9–11*: blades (No. 691), *12*: blade core (No. 690), *13*: blade core (No. 688), *14*: blade core (No. 704), *15*: blade core (No. 691), *16*: blade core (No. 699), *17*: blade core (No. 700)

resulted in the abandonment of cores at the site. The evidence obtained from this site demonstrates that skill signatures are clearly associated not with the absence of blade cores but with the absence of blades. Because the presence/absence of cores may be sometimes influenced by unusual flaking accidents, we should instead pay attention to missing blades among the refitted sets for the evaluation of technical skill levels.

There are no refitted sets that seen to reflect different levels of technical skill from concentration No. 90 at the Kamishirataki 8 site, in contrast to the case at the Hattoridai 2 site. As far as the technological features among the refitted sets show, it is probable that one or more skilled knappers manufactured blades at this spot. In other words, there is no evidence of the result of training exercises performed by novice knappers at this spot.

### 9.4.4 The Kamishirataki 2 site

The Kamishirataki 2 site was excavated from 1996 to 1997 by the Hokkaido Archaeological Operations Center (Naganuma et al. 2001). A total of 15 artifact concentrations have been identified and 432,429 tools and debitage items recovered. These artifacts are mostly debitage made of obsidian locally available at Shirataki. However, a few artifacts made of hard shale, chert, andesite, mudstone, and agate have been recovered. This site contains multicomponents from the middle to late Upper Paleolithic. The total area of excavation covers 6,925 m$^2$.

Here, I focus on the lithic assemblage from concentration Sb-9, which is spatially distinct from other concentrations (Fig. 9.14). Also, the distribution of the refitted artifacts is limited within this concentration. Other concentrations in this site appear to belong to a different cultural tradition. The assemblage from concentration Sb-9 includes gravers, end-scrapers, side-scrapers, microblades, microblade cores, blades, flakes and chips. Almost all of these artifacts are made of obsidian. The microblade cores can be typologically characterized as of the Hirosato type (Nakazawa et al. 2005; Takakura 2012). Although AMS 14C dating was not obtained from this concentration, a techno-typological evaluation on the assemblage revealed that it belongs to the late Upper Paleolithic (Naganuma et al. 2001).

There are four refitted sets No. 142 (Fig. 9.15: 1), No. 136 (Fig. 9.15: 2), No. 137 (Fig. 9.16: 1), and No. 124 (Fig. 9.16: 2) relevant to the manufacture of large blades. Descriptions of these are presented in Table 9.3. Each of them, conjoining with many blades and flakes, clearly shows how the raw materials were selected, how there was repeated preparation and rejuvenation of the blade cores, and subsequently which blades were removed. It appears that blade production of these refitted sets progressed in much the same manner.

First, large chunks of obsidian debris were commonly used as raw material, and they show sufficiently good quality for blade production. The diameters of chunks selected in this assemblage average about 40 cm. Second, formal and long blades, from almost 10 cm up to 30 cm in length, were subsequently detached during these blade reductions (Fig. 9.17). Such detachment requires multistage reduction sequences, including careful preparation and several rejuvenation stages that involve striking the platforms as well as the ridges on the blade cores. Blade removal of these refitted sets was generally executed from one striking platform—occasionally from opposed striking platforms—with one front crest. These were always connected through rubbing on the pecked platform, presumably with the aid of abrasives. Third, when hinge fracture terminations accumulated on the production face of the cores as well as the striking platforms, the knappers often rejuvenated the flaking surfaces and platforms to eliminate the accumulated errors. After that, the detachment of blades was re-initiated on the cleaned-up flaking surfaces.

Therefore, the technological features common to all of the blade refitted sets in this assemblage allow us to infer that the knappers were highly skilled at maintaining cores effective for the production of formal blades and at coping appropriately with errors. The knappers working at concentration Sb-9 in the Kamishirataki 2 site relied more on highly developed fine-motor skill than those of the Hattoridai 2 and Kamishirataki 8 sites, in order to produce formal and long blades from large chunks of obsidian debris. With regard to identifying the technical skill level involved, four of the refitted sets in this assemblage appear to be the result of knapping activity carried out at an identical skill level. Probably novices did not knap within or near concentration Sb-9 at the Kamishirataki 2 site.

It is of interest to note that many of the blades detached from the blade cores in this assemblage were abandoned at concentration Sb-9, while some of the blade cores were exported from the site. In these cases, every stage in the course of the manufacturing process was performed with the utmost precision, but almost all of the products were left on the spot, unlike at the Hattoridai 2 and the Kamishirataki 8 sites. One conclusion that can be drawn from this is that the expert knappers were not aiming at producing good blades for immediate use, but rather instructing beginners. These materials can be interpreted as "academic cores" (Johansen and Stapert 2008): cores worked by an expert knapper in what seems to have been a pedagogic demonstration for the benefit of a beginner knapper. A similar situation was also confirmed for refitted artifacts from the Pincevent site (Bodu et al. 1990). The refitted sets from concentration Sb-9 at the Kamishirataki 2 site suggest that novices had the opportunity to observe operational sequences performed by experts and to gather complex knowledge concerning the repertoire of gestures as well as advanced know-how.

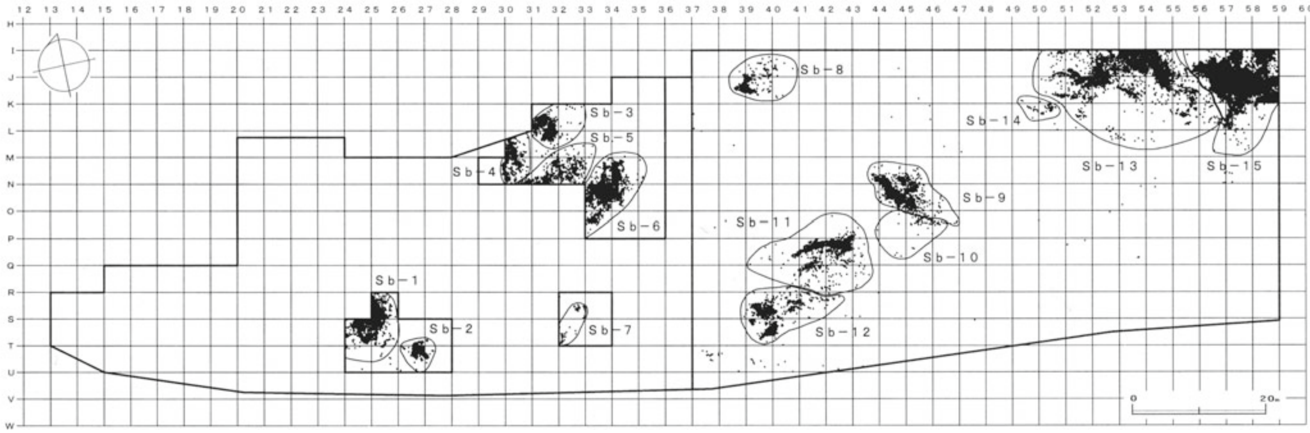


**Fig. 9.14** Distributions of stone artifacts in the Kamishirataki 2 site (Naganuma et al. 2001)

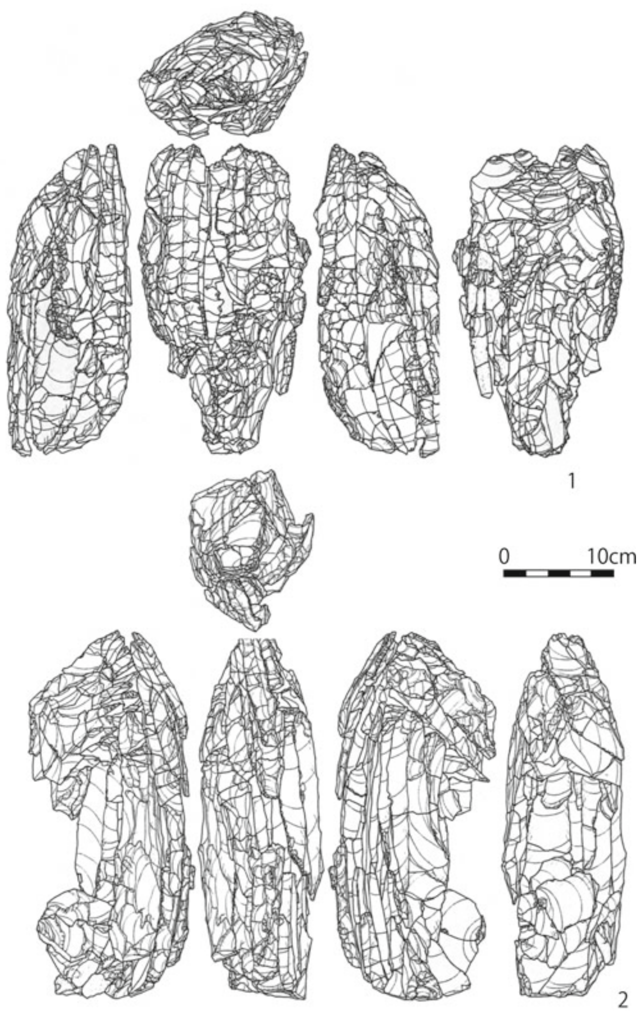


**Fig. 9.15** Refitted sets from the Kamishirataki 2 site (1) (Naganuma et al. 2001). *1*: No. 142, *2*: No. 136

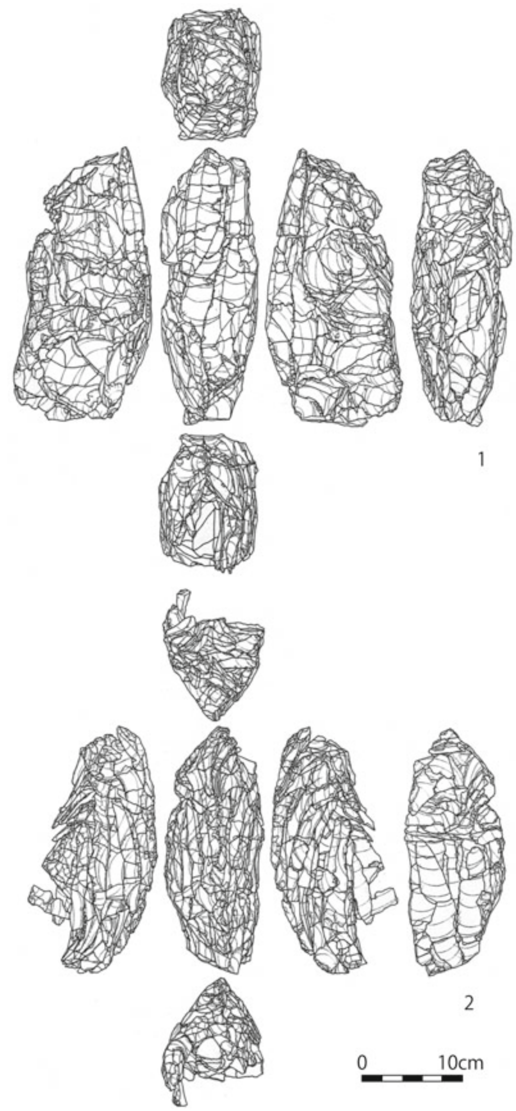


**Fig. 9.16** Refitted sets from the Kamishirataki 2 site (2) (Naganuma et al. 2001). *1*: No. 137, *2*: No. 124

**Table 9.3** Refitted sets from concentration Sb-9 at the Kamishirataki 2 site

| No. | Raw material | Size (cm) | Weight (g) | Blade core | Number of recovered blades | Total number of refitted pieces |
|---|---|---|---|---|---|---|
| 142 | Angular gravel | 37×16×18 | 5,212 | Absent | 40 | 422 |
| 136 | Angular gravel | 34×12×15 | 2,298 | Absent | 25 | 195 |
| 137 | Angular gravel | 28×10×14 | 2,231 | Absent | 14 | 278 |
| 124 | Angular gravel | 25×10×12 | 1,283 | Present | 34 | 217 |

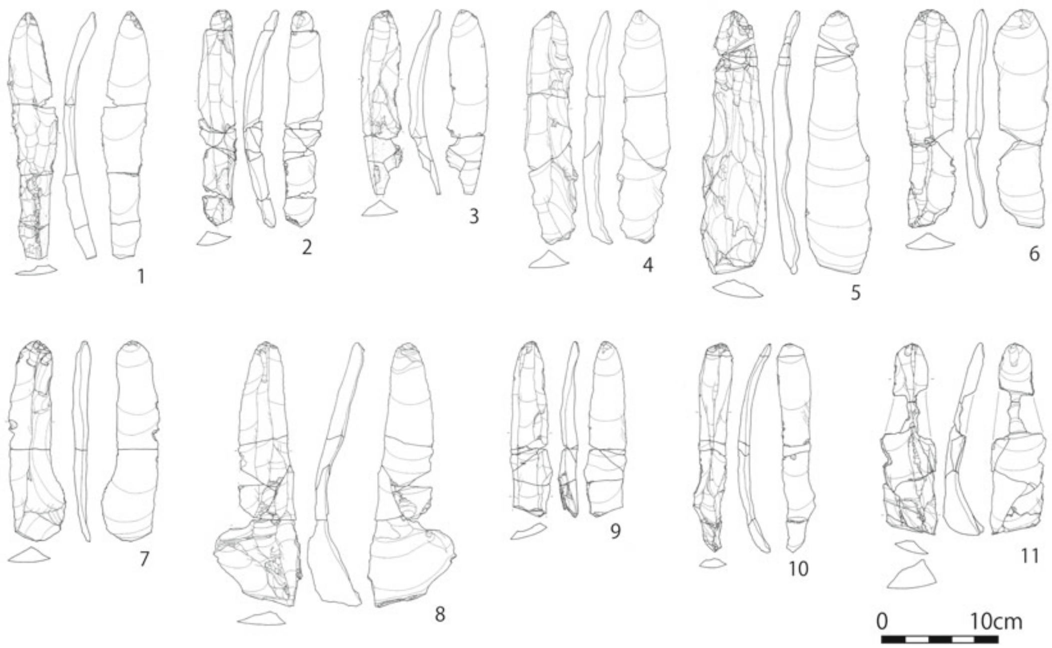


**Fig. 9.17** Blades from the Kamishirataki 2 site (Naganuma et al. 2001). *1–4*: No. 142, *5–8*: No. 136, *9*: No. 137, 10–*11*: No. 124

## 9.5 Discussion and Conclusions

This paper presents an analysis of the lithic refitted artifacts from the Upper Paleolithic assemblages at the Shirataki sites and highlights some questions as to how we can obtain information regarding knappers' skill levels in the past from an analysis of lithic refitted artifacts. As a result, I can reveal more variation than might have been previously expected both in the expressions of skill among the lithic refitted artifacts and in the evidence for training/learning processes at the Upper Paleolithic sites.

Previous studies of the learning and skill transmission process of prehistoric lithic technologies, particularly in Europe, have argued that differences in knappers' competence at lithic manufacture can be identified based on the technological characteristics of the refitted artifacts. In such studies, the spatial distributions of the refitted sets at the sites have been also analyzed to examine the place of knapping activities and the relationships between multiple knappers with different levels of skill. In this paper, I have focused on the relationship between the technological characteristics generally interpreted as skill signatures in previous studies and on the variety of raw materials, especially their size and form, in order to reconsider the hypothesis that the selection of raw material itself depended on differences in the knappers' technical skill levels.

Comparison of the lithic refitted artifacts from the Shirataki sites reveals that the particular choice of raw material "packages" is not always associated with different skill levels among knappers. In particular, the materials from concentration Sb-90 at the Kamishirataki 8 site suggest that the highly skilled knappers would occasionally use different forms of obsidian pebbles for blade production. This is different from what has been observed in the Magdalenian lithic assemblages in the Paris Basin (Audouze and Cattin 2011; Pigeot 1990, 2010). Perhaps, such difference may be related to the raw material condition at Shirataki where abundant and various obsidian raw materials could be procured nearby the sites. Anyway, it is apparent that we archaeologists need to reexamine the hypothesis that the selection of raw material itself is always conditioned by differences in technical skill levels among knappers.

As mentioned above, there are only minor differences in size between the angular and round cobbles in the refitted sets from concentration Sb-90 at the Kamishirataki 8 site. Furthermore, I have shown that the knappers involved in the formation of this assemblage had equivalent skills in blade production. Therefore, in this case the variety of shapes in the lithic raw materials did not significantly influence the formation of technological variability usually related to the expression of skill. This subsequently leads to my conclusion that the reduction sequence using the round obsidian cobbles recovered from concentration Sb-23–31 at the Hattoridai 2 site can be understood as the result of knapping episodes by novices, and not as a simplified reduction by expert knappers due to the influence of morphological features of the raw materials, because the situation relative to lithic raw materials is the same among the Shirataki sites.

To shed light on the relationship between the lithic raw materials and the technological characteristics of reduction sequences, we should instead focus on the difference in size and quality of the raw materials. In other cases it may be difficult to distinguish the results of novice knapping from some of the simplified reductions performed by experts due to the use of small and/or lower quality "packages" of raw material (e.g., Audouze and Cattin 2011; Shea 2006), given that the situation relative to raw material is not the same.

The results of analysis presented in this paper suggest that the missing blade cores ("ghost cores") as well as the missing blades ("ghost blades") among the refitted sets can offer a useful signature of the knappers' skill. In particular, that there are missing blades in the refitted sets is of more important for such an assessment because this factor is apparently correlated to the technological characteristics that reflect distinctions in the knappers' skill at the Hattoridai 2 and Kamishirataki 8 sites. Among the highly mobile foragers at these sites, who possessed blades as tools and blanks, blades were frequently exported from the localities of lithic production near raw material sources when good results were achieved technically. Thus the "ghosts" of blades may represent the results of knapping activities performed by experts. Whenever it is difficult to distinguish the results of novice knapping from the simplified reductions performed by experts, as noted above, an assessment of the "ghosts" of blades in the refitted sets might provide reliable and specific information concerning the skill levels of knappers.

Furthermore, I have drawn some conclusions concerning the skill learning process employed at the Shirataki sites for lithic production. The results of present analysis provide an impressive case study of skill learning behaviors in the production of obsidian blades. Data from the lithic refitted artifacts from concentration Sb-23–31 at the Hattoridai 2 site shows that novice knappers carried out simple training exercises at this site, sometimes also observing the performance of skilled knappers at an adjacent spot. The analysis revealed that the activity zones of the skilled knappers and novice knappers were clearly separated. It is reasonable to suppose this was based on well-defined spatial rules. This spatial segregation gives us an important clue as to the place at which knapping episodes by novices occurred at this site. Such spatial patterning demonstrates that knapping episodes by novices did not co-occur with that by experts. The differentiated activity zones, inferred through analysis of the Hattoridai 2 site, suggest that both groups of knappers probably paid attention to the other's knapping activities, either explicitly or implicitly. The novices may have been expected to learn by watching the work of experts and then imitating it by themselves. A similar learning process was also confirmed by Grimm (2000).

Ethnographic studies of learning in "small scale societies" have stressed that learning through observation and imitation played an essential role in transmitting knowledge and know-how with regard to craft activities and subsistence from adults to children or adolescents (e.g., Gaskins and Paradise 2010; Hayden and Cannon 1984). The results of analysis from the Hattoridai 2 site may confirm the significance of skill learning through observation and imitation in the context of a prehistoric site.

In contrast, the refitted sets from the Kamishirataki 2 site show that pedagogical demonstrations for the benefit of novices might have been performed there by expert knappers in a more formal context. It is important to note that the expert knappers in this case were not aiming at producing good blades for immediate use, but rather at instructing novices. This case suggests a kind of "teaching" of skill through reduction of "academic cores", although it remains unclear whether or not this was associated with verbal instruction. This is in contrast to ethnographically based claims that this kind of formalized training/learning process is rare among "small scale societies", and in particular forager societies. Such a hypothesis for the refitted sets from the Kamishirataki 2 site may reinforce a necessity of different interpretations for making sense of skill learning process in forager societies, if it occurred not only through careful observation of the operational sequence used by experts and imitation of it, but also through mutual cooperation and a kind of "teaching" of beginners by experts' demonstrations.

According to Hayden and Cannon (1984) and Bamforth and Finlay (2008), self-taught activities, including a degree of trial and error, tend either to be those that are not related to craft production or those that rely more on coarse-motor skills than on highly developed fine-motor skills. As I have suggested here, it is evident that a highly developed level of fine-motor skill was needed for successful blade production at the concentration Sb-9 in the Kamishirataki 2 site, and this perhaps might have resulted in the characterization of the training/learning process at the site. Furthermore, it is important that the training/learning process through a kind of "teaching" of skill was also recognized in the Magdalenian site of France (Bodu et al. 1990). This encourages us to suppose that such process was not a restrictive phenomenon which might have been only seen in the Upper Paleolithic site of Hokkaido, Northern Japan. It brings focus to reconsider a role of some kind of "teaching" involving instruction in the skill transmission process for the highly developed craft production in prehistoric contexts. Of course, definitive conclusions are not easy to draw but the apprenticeship process of prehistoric lithic knappers is far more complex than was previously supposed.

Looking at the results of the refitted artifacts from the Shirataki sites, it is significant that these skill learning behaviors occurred at sites in which the obsidian cobbles favored for use as lithic raw material could be easily and abundantly acquired. Working through trial and error, novice knappers would have likely created vast quantities of debitage (Shea 2006). The availability of raw materials probably permitted such a degree of trial and error by novice knappers or pedagogic demonstration by expert knappers. Therefore, we can conclude that novices were present in camps used for the procurement of obsidian raw materials and the production of blanks and tools. This encourages us to look for traces of children and adolescents in these hunter-gatherer camps at Shirataki. This in turn may eventually provide critical insights into the local group organization composed of men, women, and children, as well as the settlement pattern of prehistoric hunter-gatherers during the late Upper Paleolithic.

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