

# *Use Angle and Motional Direction of End Scrapers: A Case Study of the Palaeolithic in Hokkaido, Japan*



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## INTRODUCTION

END SCRAPERS ARE ONE OF THE ESSENTIAL ARTIFACTS in human prehistory studied by archaeologists not only in Japan, but elsewhere in the world. Because these artifacts are highly conducive to stylistic embellishments, they provide significant clues for chronological investigation and study of the relationships between sites. The highly curated aspects of end scrapers as a tool also offer valuable information about reduction sequences and functional systems of stone tools (Barnes 1932; Shott 1995; Siegel 1984). Furthermore, this tool is often associated with fur/hide resource processing, clothing which is indispensable for humans, especially in mid- and high-latitude zones. The function-specific character of end scrapers makes it easier for us to examine issues related to the history of technology, the division of labor, gender, social stratification and the symbolism of power (Frink and Weedman 2005; Hayden 1979, 1990, 1993; Semenov 1964).

In studies of the Palaeolithic in the Japanese Islands, end scrapers have played an important role not only in chronology, but also in discussions identifying human groups and their adaptation to cold climates. Arguments in the past concerning cultural attributions and adaptive strategies were not necessarily backed up by sufficient evidence on the use and functions of end scrapers. However, in the last decade, lithic use-wear analysis has demonstrated that the Palaeolithic end scraper was one of the principal tools for hide-working (Kanomata 2003, 2004, 2008; Takase 2003, 2008*b*; Tsutsumi 1997*a*, 1997*b*, 1999, 2000).

Nevertheless, very few attempts have been made to investigate in detail the specific mechanics of how end scrapers were used. For example, little is known about the direction of tool movement and the hafting method, although these provide basic information for discussing the technology of hide processing and the tool use strategies of hide-workers. The objective of this article is to demonstrate a method for estimating the direction of tool movement of end scrapers, focusing specifically on the relationship between the use angle and the edge angle (Fig. 1).

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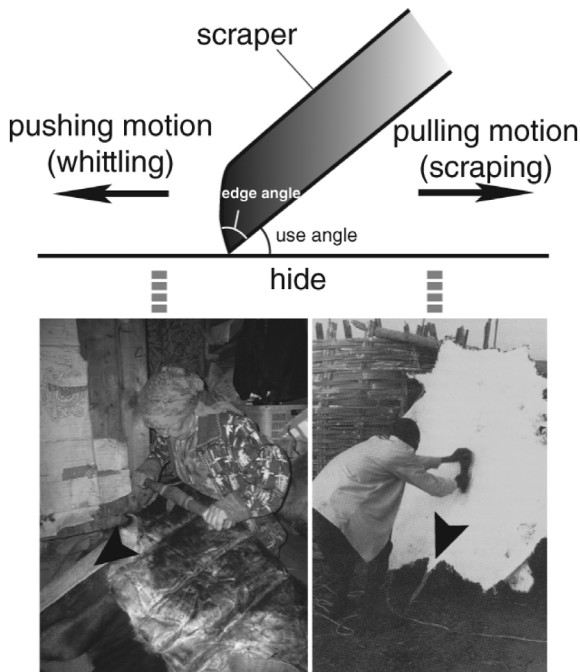


Fig. 1. The direction of tool movement of end scraper. Lower left photograph: Even women in central Kamchatka, processing hide using a scraper in a pushing motion; lower right photograph: a Chawa tanner in Ethiopia scraping hide in a pulling motion (after Clark and Kurashina 1981).

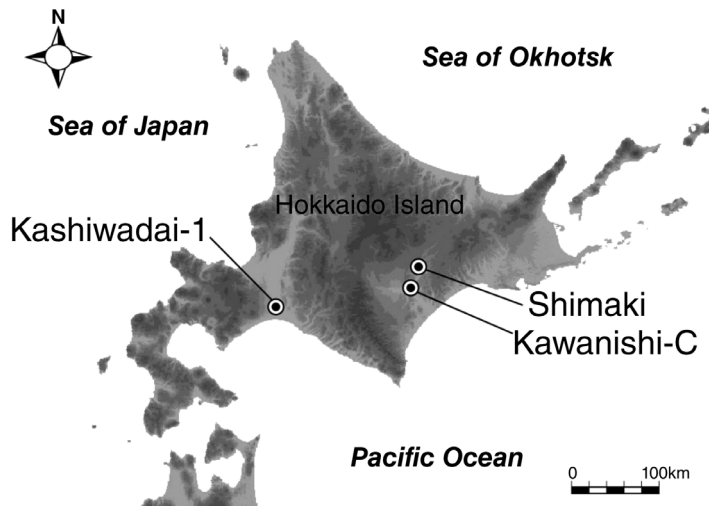


Fig. 2. Map showing location of sites.

#### SPECIMENS ANALYZED

The database for the present study consists of end scrapers from three late Palaeolithic sites in central and eastern Hokkaido Island: Shimaki (Kato and Yamada 1988), Kashiwadai-1 (Loc. B, Fukui and Koshida 1999), and Kawanishi-C (Pre-pottery II phase, Kitazawa et al. 1998) (Fig. 2). The ratio of end scrapers in each assemblage of

flaked stone tools omitting blade, flake and chip tends to be high (about 25–75%), so therefore end scrapers are one of the most representative tools of the period (Table 1).

Since the 1970s, lithic assemblages characterized by unstandardized tool forms and a high frequency of end scrapers have been thought to be the oldest component in prehistoric Hokkaido (e.g., Education Board of Chitose City 1974; Tsuji 1973). This perspective has been supported by materials found under the En-a tephra layer (c. 19,000 to 21,000 B.P.) in the 1990s (Fukui and Koshida 1999; Kitazawa et al. 1995, 1998). According to recent chronological studies, they should be regarded as artifacts assigned to the first half of the late Palaeolithic in Hokkaido (Izuho and Akai 2005; Terasaki 2006; Yamada 2006). Radiocarbon dates of charred material from the cultural layer at Shimaki is 23,800 B.P. (Kato and Yamada 1988), and  $21,420 \pm 190$  B.P. and  $21,800 \pm 90$  B.P. at Kawanishi-C (Kitazawa et al. 1998). In Kashiwadai, 30 results of AMS dating of charred material collected from layers under the En-a tephra show dates ranging from  $37,350 \pm 550$  B.P. to  $18,840 \pm 150$  B.P. (Fukui and Koshida 1999). They are consistent with the recognized date of the En-a tephra layer and there is still no reliable lithic assemblage older in Hokkaido. As far as the purpose of this study is concerned, it is not necessary to investigate a detailed chronology. Therefore, the present article will be based on the assumption that all specimens from the three sites belong to the same chronological phase (i.e., the first half of the late Palaeolithic).

The end scrapers from these sites number about 400. The common technological characteristics are unifacial flaking, a convex bit in plan view, and a plano-convex lateral section. Almost all of the artifacts are made from obsidian and hard shale.

End scrapers from Kashiwadai-1 and Shimaki tend to be made on relatively small, short, and round-shaped flakes (Fig. 3:1–18). In contrast, a lot of end scrapers made on blades and on relatively long flakes are included in the materials from Kawanishi-C (Fig. 3:19–22). It is also noteworthy that concentrations of microblade and non-microblade industries have a different spatial distribution in Kashiwadai-1.

#### METHODS AND RESULTS OF ANALYSES

The first step of the study was to choose end scrapers with heavy edge abrasion that is visible to the unaided eye. Then, use-wear analysis by the “high-power approach” (Keeley 1977, 1980) was performed using an incident light microscope (OLYMPUS BX-30M) with a magnification from 100x to 500x to ensure that these tools were used for hide-working.

As a result of observation by the naked eye, it was clear that 34 end scrapers (about 8% of the total specimens) had severe abrasions on their working edges. Thirty-three of them had typical “dry-hide/leather polish” (Keeley 1980) or “E2 type polish” (Akoshima 1989; Kajiwarra and Akoshima 1981). On these specimens, striations perpendicular to the edge were observed with the use-wear polish without exception (Fig. 4). Results of use-wear analysis strongly suggest that the end scrapers were used for hide-working. One specimen with “bone polish” was not considered in this article.

The problem that we have to consider next is the use angle of the 33 specimens with the dry-hide/leather polish. The use angle is the tool inclination against the hide surface when a scraper is in use. In the case of a unifacial end scraper, it can be evaluated by measuring an angle formed by the ventral face and the abrasive wear surface.

TABLE 1. TOOL COMPOSITION OF EACH SITE

SITE	MICROBLADE	BLADE	BURIN	END SCRAPER	SIDE SCRAPER	RETouched OR UTILIZED FLAKE	DRILL-SHAPED TOOL	PIECE ÉQUILIBRÉE	MICROBLADE CORE	CORE	FLAKE	CHIP	POINT	BURIN SPALL	TOTAL
Kashiwadai-1 Loc. B (Fukui and Koshida 1999)	638	46	4	266	70	442	13	36	5	118	7678	20,806	0	0	30,122
Kawanishi-C Pre-pottery II phase (Kitazawa et al. 1998)	0	0	39	66	82	55	7	1	0	1	407	16,603	0	60	17,321
Shimaki (Kato and Yamada 1988; Tsuji 1973)	4	0	1	57+	7+	38+	6	2	1	41		817+	3	0	977+

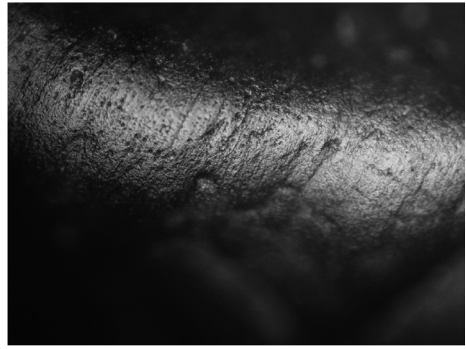


Fig. 3. End scrapers of the first half of the late Palaeolithic in Hokkaido (1–14: Kashiwadai-1; 15–18: Shimaki; 19–22: Kawanishi-C).

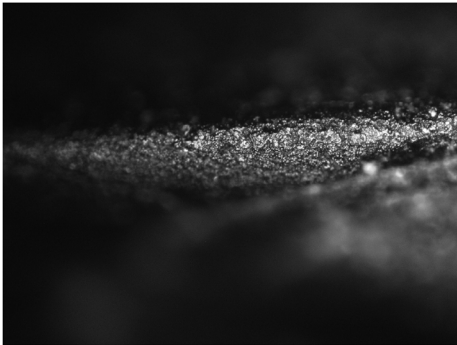
The replication method is appropriate to measure the use angle accurately. After the working edges of the specimens were replicated with silicone-rubber impression material made for dentistry (“Tokuso Fit Tester,” Tokuyama Dental Co. Ltd., Japan) (Fig. 5), the replicas were sliced vertically with a razor blade. In order to slice replicas in a suitable position for measuring the use angle, before putting the silicone on the stone tools, it can be effective to use an extremely soft graphite pencil (e.g., 9B) to dot a minute point on the tip of the ventral face with the most severe abrasion. A point created by the black particles will be copied to the inside of the replicas; this will be the mark to cut (however, a graphite pencil is not used in Figure 5). The sliced replicas were observed with a stereoscope (OLYMPUS SZX-7) at the magnification of



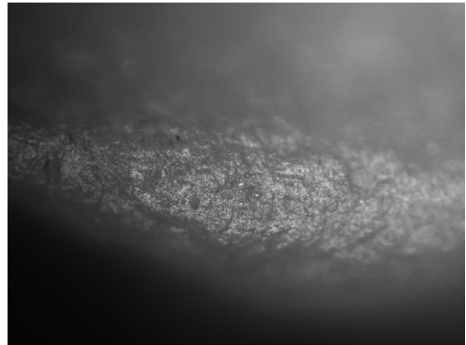
1 Kashiwadai-1 No. 180 (100 x)



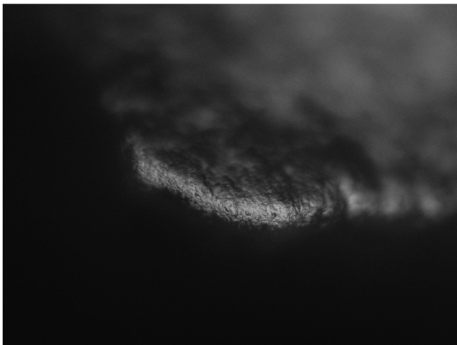
2 Kashiwadai-1 No. 196 (100 x)



3 Kashiwadai-1 No. 107 (100 x)



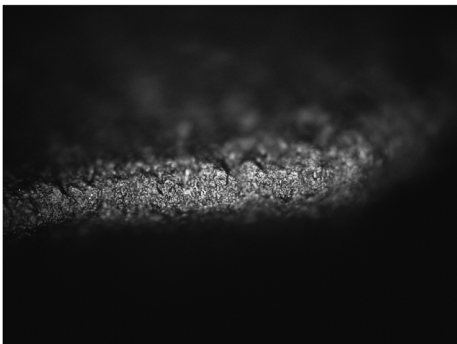
4 Kashiwadai-1 No. 164 (100 x)



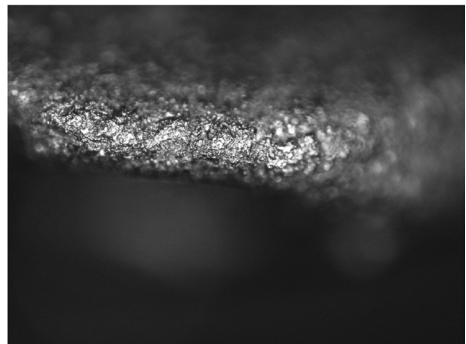
5 Kashiwadai-1 No. 242 (100 x)



6 Shimaki SK89.B13.27 (100 x)



7 Shimaki SK87.J22.5 (100 x)



8 Kawanishi-C Fig. 16-2 (100 x)

Fig. 4. Micrographs of use-wear polish on end scrapers (width of photograph: 600  $\mu$ ).



Fig. 5. Replicating the edge of an end scraper using silicone-rubber (1) and its inside view (2).

40x–80x. Graphite particles that remain on stone tools can be easily removed by using a kneaded eraser.

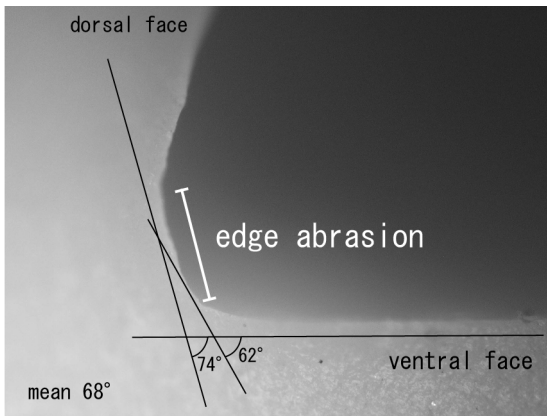
Clay might be used as an option to create replicas using a technique that Burgess and Kvamme (1978) introduced to measure the edge angle. However, clay is not necessarily suitable mold material for measuring the edge angle, because it often causes accidental errors due to deformation. In addition, it is difficult to convey clay replicas preserving their shape in field and on-site investigation (e.g., ethnoarchaeological survey and research overseas). In case of accurately measuring the edge angle at higher magnification, such a risk of mold modification should be reduced.

On the other hand, silicone is a highly reproducible material for observing the surface of stone tools as d’Ericco (1988) demonstrated. Furthermore, it has excellent properties to preserve its shape and moderate flexibility, although it is fluid enough to make replicas of various forms of stone tools before it becomes indurated. It does not damage fine stone such as obsidian; in the case of coarse-textured stone, mold lubricant (e.g., 5–7 wt% Palaroid B72 acetone fluid) enables protection of the surface of the specimen.

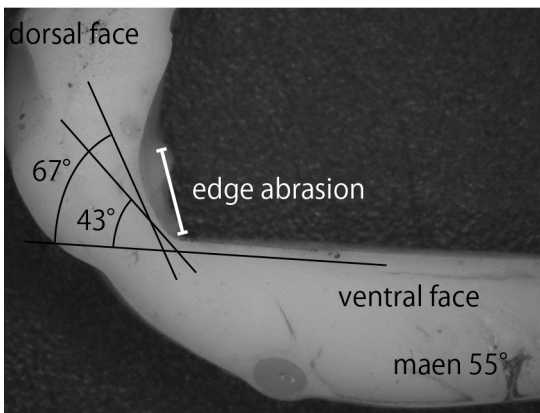
Figure 6 shows a cross section of replicated working edges. In the case of the specimen shown in Figure 6-1, the use angle is between  $62^\circ$  and  $74^\circ$ , and the mean angle is  $68^\circ$ . Such a replica method is more effective to accurately measure the use angle than observing the working edge sideways directly with a stereoscope. The abrasive wear surface has a tendency to be relatively stable and flat, regardless of the period. In most cases, the difference between the two extreme values of the use angle is less than  $25^\circ$ . Mean value of the use angle is shown in Table 2. The mean edge angle was obtained by values measured on five points in the working edge with a protractor.

#### DISCUSSION

The motional direction of an end scraper is divided into two categories: a “pushing motion” and a “pulling motion” as shown in Figure 1. The former is called “whit-



1



2

Fig. 6. Cross section of a replica (1: Kashiwadai-1, No. 34; 2: Kashiwadai-1, No. 196).

tlings,” and the latter is known as “scraping” in the terminology of experimental archaeology. Generally, the morphological features of end scrapers require a smaller use angle in the case of a pushing motion, while the use angle tends to be larger when the end scraper is used in a pulling motion. Experimental archaeology has revealed that a pushing motion produces a higher frequency of micro-flaking and more distinctive striation on the ventral face than on the dorsal face (Barnes 1932:52–53; Odell 1981:202–203).

According to ethnographic sources for Northeast Asia, the average use angle is  $34^{\circ}$  when an end scraper is used in a pushing motion (Bogoras 1904–1909; Jochelson 1908; Takase 2004). The use angle of scrapers with crooked and straight hafts used in a pushing motion in Alaska and Arctic Canada is less than  $45^{\circ}$  (Murdoch 1893:294–295; Nelson 1899: Pl. XLIX). Some micro-flakings can be seen on the ventral face of these ethnographic materials (Nissen and Dittmore 1974:70). However, results of experimental archaeology have showed that micro-flakings are not often formed through tanning (Tringham et al. 1974:189), because animal hide is not a very hard material. In addition, the author also confirmed that the number of micro-flakings on



TABLE 2. RESULTS OF ANALYSIS

NO.	SITE	NUMBER IN FIG. 3	NO. IN REPORT	STONE	MEAN EDGE ANGLE (DEGREES)	MEAN USE ANGLE (DEGREES)	MEAN VALUE OF THE INDEX OF TOOL INCLINATION	GROUP	HEAVY WEAR ON WORKING EDGE VIEWED FROM THE DORSAL FACE
1	Kashiwadai-1	1	Fig. V-12-15	obsidian	77	38	0.73	B	right
2	Kashiwadai-1	2	Fig. V-12-18	obsidian	80	38	0.76	B	left
3	Kashiwadai-1	3	Fig. V-13-34	obsidian	75	68	1.33	A	center-left
4	Kashiwadai-1	4	Fig. V-13-42	obsidian	80	39	0.65	B	center-left
5	Kashiwadai-1	5	Fig. V-13-54	obsidian	83	47	0.77	B	left
6	Kashiwadai-1	6	Fig. V-14-73	obsidian	77	35	0.68	B	center
7	Kashiwadai-1	7	Fig. V-15-100	obsidian	69	40	0.71	B	right
8	Kashiwadai-1	8	Fig. V-15-107	obsidian	97	45	1.07	A	center
9	Kashiwadai-1	9	Fig. V-16-139	obsidian	85	58	0.44	B	center
10	Kashiwadai-1	10	Fig. V-18-161	shale	72	29	0.53	B	left
11	Kashiwadai-1	11	Fig. V-19-180	shale	74	36	0.68	B	center-right
12	Kashiwadai-1	12	Fig. V-18-164	shale	86	26	0.56	D	center-left
13	Kashiwadai-1	13	Fig. V-20-196	shale	100	55	1.38	C	center
14	Kashiwadai-1	14	Fig. V-23-242	chert	67	17	0.33	B	center-left
15	Shimaki	15	SK87.J22.5 (Fig. 20-4)	obsidian	68	45	0.80	B	center
16	Shimaki	16	SK87.D23.23 (Fig. 20-6)	obsidian	57	57	0.93	B	right
17	Shimaki	17	SK87.D22.27 (Fig. 21-11)	obsidian	68	43	0.77	B	left
18	Shimaki	18	SK87.O22.6 (Fig. 21-13)	obsidian	79	39.5	0.79	B	right
19	Shimaki	-	SK89.B14.49	obsidian	73	56	1.05	A	right
20	Shimaki	-	SK87.B14.2	obsidian	67	43.5	0.77	B	center
21	Shimaki	-	SK89.C14.2	obsidian	90	60	1.33	A	left
22	Shimaki	-	SK89.B13.27	obsidian	61	51	0.86	B	center
23	Shimaki	-	SK89.B13.6	obsidian	39	40	0.75	B	center
24	Shimaki	-	SK89.D14.3	obsidian	66	37	0.60	B	center
25	Shimaki	-	SK88.G43.1	obsidian	77	56	1.09	A	left
26	Shimaki	-	SK87.L7.125	obsidian	77	54	1.05	A	center
27	Shimaki	-	SK87.D22.21	obsidian	74	48	0.91	B	left
28	Shimaki	-	SK87.L7.25	obsidian	88	41.5	0.91	B	left
29	Shimaki	-	SK87.M9.85	obsidian	67	41.5	0.74	B	center
30	Kawanishi-C	19	spot 2-10	obsidian	80	35	0.70	D	center-right
31	Kawanishi-C	20	spot 3-17	obsidian	93	42	0.95	D	center-left
32	Kawanishi-C	21	spot 8a-16	obsidian	73	48	0.89	D	right
33	Kawanishi-C	22	spot 8b-3	obsidian	82	33	0.67	D	right

ethnographic stone scrapers used in the Kamchatka Peninsula and Alaska is very small, even if a tanner keeps using these tools for a long time until severe abrasive wear is formed on the edge. Therefore, the lack of micro-flaking on the ventral face does not necessarily suggest that the end scraper was not used in a pushing motion.

In a pulling motion, micro-flaking and striation is more remarkable on the dorsal face than the ventral face (Barnes 1932:52–53; Clarke and Kurashina 1981:312; Odell 1981:200–201; Semenov 1964:88; Tringham et al. 1974:189, 191; Wilmsen 1968:159). The use angle is 70°–90° in ethnographic records in Ethiopia, where end scrapers are used only in a pulling motion (Brandt 1997:735–736; Brandt and Weedman 1997:353; Brandt et al. 1996:40; Gallagher 1974:177–181, 1977:411; Weedman 2002:734). However, tanning in a pushing motion does not always produce a lot of micro-flakings on the dorsal face, because the hide is not so hard as to generate a consistent amount of micro-flaking (Rots and Williamson 2004:1290). In addition, it is not easy to distinguish micro-flakings caused by using tools from those caused by making tools. Therefore, the frequency of micro-flaking is not always a crucial indicator to estimate the direction of tool movement of end scrapers.

To overcome this problem, the author developed an interpretative model to estimate the direction of tool movement from the viewpoint of the relationship between the use angle and the edge angle (Takase 2005). In Figure 7, the vertical axis covers

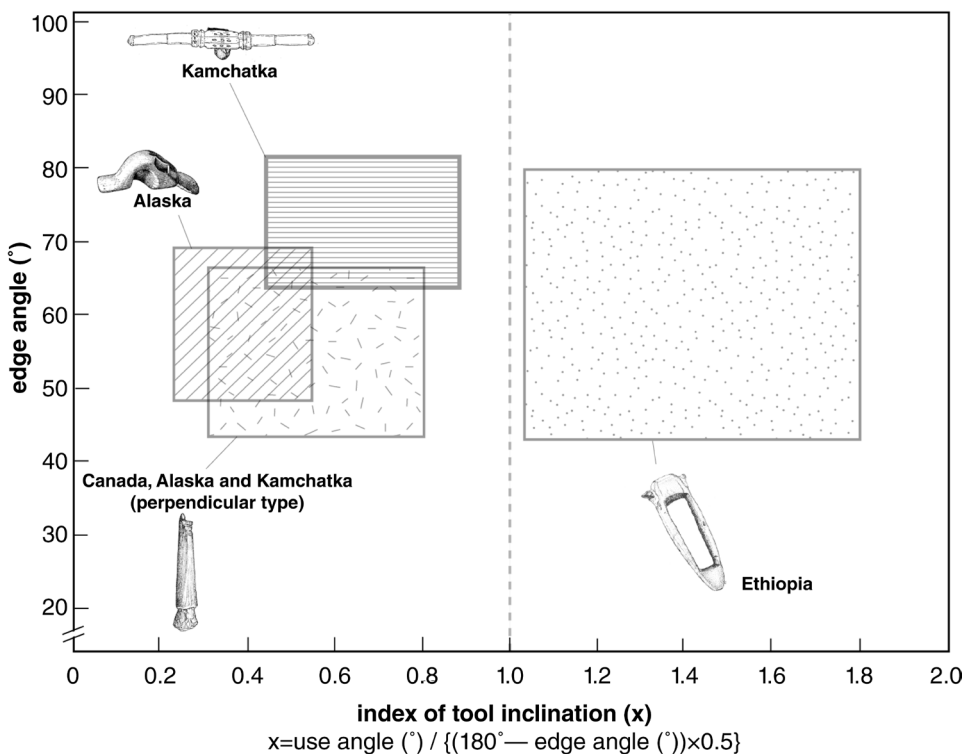


Fig. 7. A model for estimating the direction of end scraper tool movement. Sources: Ethiopia—Clark and Kurashina 1981, Gallagher 1977; Alaska and Canada—Murdoch 1892, Nissen and Dittmore 1974; Kamchatka: Takase 2004.

the edge angle and the transverse axis provides an index of the tool inclination of the end scraper during use. This index (x) is calculated using the following equation:

$$x = \text{use angle}(\text{°}) / \{(180\text{°} - \text{edge angle}(\text{°})) \times 0.5\}$$

If the index value is larger than 1.0, the end scraper is interpreted to be used in a pulling motion like that of Ethiopian tanners. In contrast, a value smaller than 1.0 suggests that the end scraper was used in a pushing motion. According to ethnographic descriptions around the Bering Strait and my own ethnoarchaeological survey in the Kamchatka Peninsula, all stone scrapers used in a pushing motion show a smaller value than 1.0 (Fig. 7). Therefore, the index has a correlation to the direction of tool movement of end scrapers used among indigenous peoples who scrape hide and skin with flaked stone tools. Referring to this model, the motional direction of prehistoric end scrapers from Northeast Asia has already been investigated (Takase 2006, 2008*a*, 2008*b*, 2008*c*).

Figure 8 shows the result of such an analysis of specimens from the late Palaeolithic in Hokkaido. A cross-shaped mark indicates relatively short end scrapers (under 6.0 cm in length) from Kashiwadai-1 and Shimaki. They were estimated to be used in both pulling and pushing motions, but the dominant direction of tool movement is a pushing motion. The edge angle of specimens used in a pulling motion tends to be higher than that of specimens used in a pushing motion.

In Figure 8, a circular mark indicates relatively long end scrapers (6.0 cm and longer in length) made on flakes and blades from Kawanishi-C and Kashiwadai-1. This model suggests that they were also used in both pushing and pulling motions. The edge angle of these specimens holistically tends to be high compared with that of small end scrapers used in a pushing motion. The dominant direction of tool movement is a pushing motion.

There were at least two ways of using end scrapers in the first half of the late Palaeolithic in Hokkaido: a pulling or a pushing motion. Furthermore, end scrapers are classified into four groups from a techno-functional point of view. Group A includes specimens made on relatively short and small flakes that were used in a pulling motion. Group B contains end scrapers made on similar flakes as group A, but they were thought to have been used in a pushing motion. Group C includes tools made on a relatively large flake that were used in a pulling motion, and group D contains end scrapers made on blades or relatively long flakes that were used in a pushing motion. These results offer support for a hypothesis about utilization of Palaeolithic end scrapers in Hokkaido submitted by Kato et al. (1970), although their materials should be assigned to a younger archaeological stage than specimens examined in the present article.

Semenov (1964:87–88) pointed out that severe wear could be seen on the right part of the working edge on 80 percent of the Palaeolithic end scrapers from Europe and the Russian territory. These end scrapers were believed to have been used in a pulling motion and held with the right hand without hafting. Materials from North America are also supposed to be used in a similar way (Wilmsen 1968:157), while some archaeologists assert the possibility of hafting and another direction of tool movement should be taken into consideration (Kato et al. 1970; Shott 1995; Takase 2004; Yamanaka 1976).

Specimens in group A tend to show heavy abrasion in the middle and the left part of the working edges (Table 3). On the other hand, observation reveals a tendency

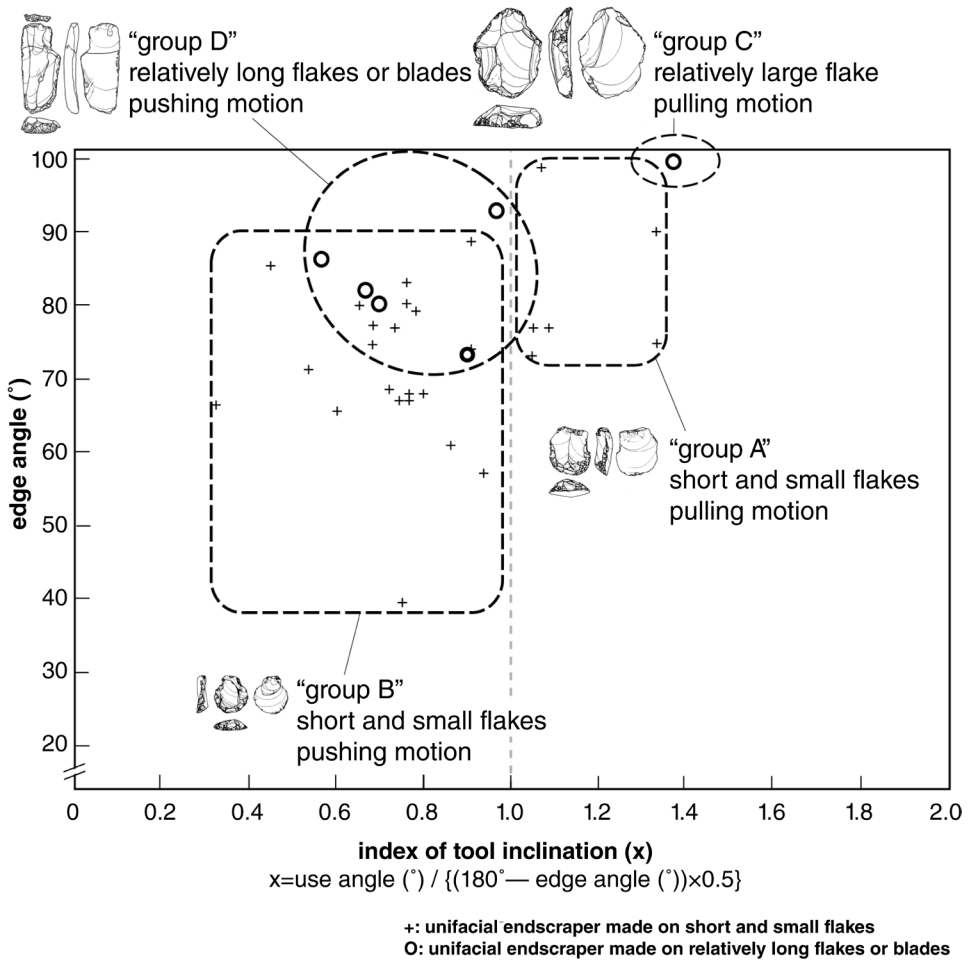


Fig. 8. Result of estimation of the direction of tool movement.

TABLE 3. PART OF HEAVY WEAR ON THE WORKING EDGE VIEWED FROM THE DORSAL FACE LAYING THE WORKING EDGE UP

GROUP	LEFT	MIDDLE-LEFT	MIDDLE	MIDDLE-RIGHT	RIGHT
A	2	1	2		1
B	6	2	8	1	4
C			1		
D		2		1	2

toward severe wear in various parts of the working edges of groups B, C, and D. This might be interpreted as an effect of a different grasping or hafting method. In fact, there are some specimens among group A from Shimaki with wear traces showing attachment to a wooden haft (Takase 2003). Further inspection of hafting will provide

valuable information in the future for understanding the diverse applications of end scrapers during this period.

As mentioned above, the direction of tool movement of end scrapers had already been attempted by observations of use breakage on the working edge. However, edge damage is not always a universal sign of hide processing. The method discussed in this article has an advantage, because it is available regardless of the existence of micro-flaking. At the same time, its range of application is limited to specimens with heavy edge abrasion. Therefore, the results derived from the method do not necessarily apply to all end scrapers within a period.

From this point of view, combining several methods such as low- and high-power approaches of lithic use-wear analysis and techno-morphological attribute analysis will gain in importance as a means of studying end scrapers in the future. The advantages and disadvantages of each method should be recognized and taken into consideration in interpreting the results of these methodologies. Nevertheless, there is no doubt that promoting cooperation between scholars with different archaeological approaches is inevitably important in improving our examination of tool use strategies in hide production, curation systems, and reduction sequence of end scrapers.

#### CONCLUSIONS

The results of this study can be summarized as follows. First, we can confirm that in the first half of the late Palaeolithic in Hokkaido, end scrapers were one of the principal tools for hide-working. In addition, end scrapers were used both in a pulling and a pushing motion. Exploring further the role of scraper shape and edge angle in particular, relatively short end scrapers were used in both a pulling (group A) and a pushing motion (group B). However, among these end scrapers, a pushing motion is the dominant direction of tool movement, and the edge angle of specimens used in a pulling motion tends to be higher than that of specimens used in a pushing motion. Relatively long and large end scrapers were also used in a pulling motion (group C) and a pushing motion (group D); however in this case, pushing is the dominant direction of tool movement. The edge angle of these specimens has a tendency to be higher than that of relatively small end scrapers.

There is still no detailed traceological data for comparing this directionality of scraper use in the first half of the Palaeolithic with the succeeding period. However, it is notable that small end scraper on blade and burin became dominant in tool composition in the second half of the Palaeolithic in this region. In addition, ratio of end scrapers to the all chipped stone tools has a tendency to decrease. This fact is suggestive not only of change in hide-working technology, but also of change in the need for hide products in the society.

It is possible to make hide products using only an iron knife as described in ethnographies of the Ainu in Hokkaido. On the other hand, various tools and their diverse ways of use distinctly play an important role for making different kinds of high-quality hide products using animal and fish skin among the Tungus and “Palaeo-asiatic” peoples. Modern skillful hide-workers in Kamchatka tend to try to prepare a lot of instruments, with delicate differences of their tool characteristics such as plan view of stone edge, edge angle, kind of stone, and form and size of haft (Takase 2004). If the variety of tools and their use have a close relationship with social needs for hide products, it is likely that different situations appeared in the second half of the

Palaeolithic in Hokkaido. Inspection of this estimation from the point of view of scraper and burin use is a priority for future studies.

Moreover, the methodology performed in this paper has a broad applicability to artifacts after the Jomon period, the Mesolithic, and the Neolithic; even in the modern age, this method can contribute to reveal stone scraper use and its social background. These studies lead us to an understanding of the long-term history of hide use—one of the most important resources for human beings.

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## ABSTRACT

This article examines the direction of tool movement of end scrapers used by Palaeolithic peoples for hide-working in the Japanese Islands. Specimens are approximately 400 end scrapers from three sites dated to the first half of the late Palaeolithic in Hokkaido, northern Japan. As a result of examination using a method combining the high-power approach of lithic use-wear analysis with a replication technique for measuring the edge angle and the use angle, it was clarified that end scrapers were used only for hide-working. They were classified into four groups: (1) relatively short end scrapers used in a pulling motion (group A); (2) relatively short end scrapers used in a pushing motion (group B); (3) relatively long and large end scrapers used in a pulling motion (group C); and (4) relatively long and large end scrapers used in a pushing motion (group D). Groups B and D (i.e., for pushing motion) are dominant among whole specimens. This study will contribute significantly to the investigation of tool use strategies, curation systems, and the reduction sequences of end scrapers when compared with results of techno-morphological research. At the same time, the methodology performed for this article enabled to change of needs for hide products in prehistoric society. KEYWORDS: Palaeolithic, Japan, Hokkaido, stone tools, end scrapers, lithic use-wear analysis.