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Use-wear analysis of stone tools from the coast of Karaga Bay, Northeastern Kamchatka, Russia

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Abstract: This study examined the functions of chipped and ground stone tools from the coast of Karaga Bay in Northeastern Kamchatka, Russia. The specimens analyzed include 27 stone tools restored after the excavations at the Karaga 6 (11th to 13th centuries) as well as the Karaga 10 and 13 (15th to 17th centuries) sites in 2012. The high-power approach of the lithic use-wear analysis was applied. Because of microscopic observations, six specimens displayed distinct use-wear polish. Polish morphology indicated that two utilized flakes and a retouched flake were used for hide working, while a side scraper exhibited a use-wear polish that was mainly generated by plant working. Two end scrapers also showed traces of plant working, whereas evidence of dry hide tanning was found on one specimen. The findings show that utilized or retouched flakes, not end scrapers, were the main tools for hide working from the 11th to 17th centuries C.E. in Northeastern Kamchatka. This result is extremely suggestive for the explanation concerning the diffusion process of the Paleo-Asiatic type scrapers that have been used by the indigenous peoples in Kamchatka. Finally, ethnographic implications regarding the long-term history of stone scrapers are discussed.

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Introduction

The purpose of this study is to reveal resource use on the coast of Karaga Bay from the 11th to 17th centuries C.E. through the functional analysis of stone tools. In Northeastern Kamchatka, Neolithic sites were found along the rivers and inland mountainous regions, but limited sites have been discovered along the coast. However, the number of sites rapidly increased after the occurrence of pottery in the 11th century C.E., thus suggesting that full-fledged maritime adaptation was developed during this period. In fact, a lot of harpoon heads and fishhooks were found, as well as numerous sea mammal and fish bones, at these archaeological sites. However, since limited information regarding resource use during that time exists, this study examines the relationship between stone tools as resource processing implements and natural resources.

It also examines the spatial difference of hide working technology in Northern Kamchatka.

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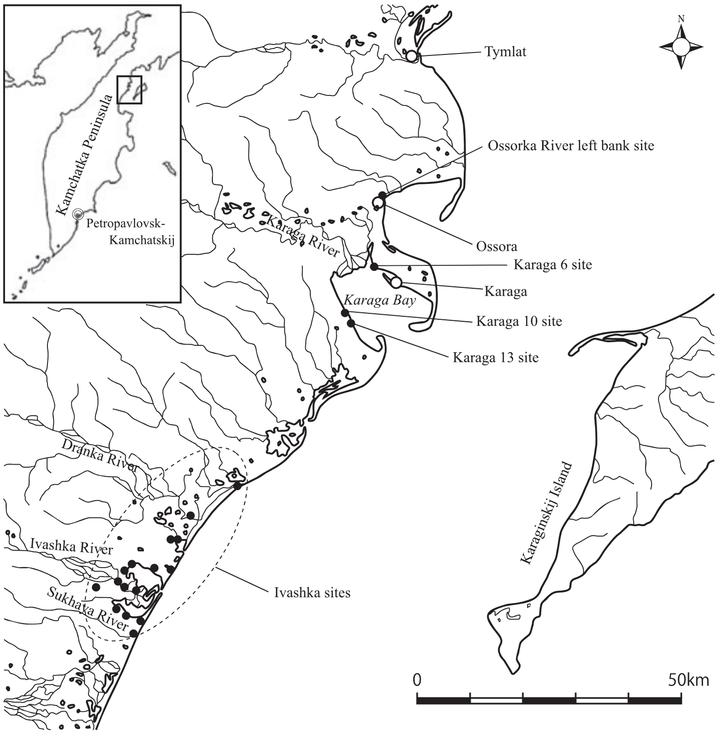


Figure 1 Map showing location of sites

Ethnographic documents demonstrate that a double-handled scraper with a stone edge attached to the center of the wooden haft, known as the Paleo-Asiatic type scraper, have been the main tool for hide processing among the indigenous peoples of Northern Kamchatka. Current archaeological research have revealed that this type of scraper most likely dates back before the 17th century, although it was not the exclusive scraper for hide working during that period (Takase 2012). However, the origin and diffusion process of this scraper has not yet been thoroughly explained. Given that the detailed use of the scraper can be provided, such information can help estimate its origin and diffusion process. Therefore, this study also discusses the ethnographic implications regarding the long-term history of human hide use.

1. Materials

The materials analyzed in this study include 27 chipped and ground stone tools (Table 1) that were collected from three archaeological sites along the coast of Karaga Bay in 2012 (Fig. 1, Takase 2014). The Karaga 6 site is located near the settlement of the First Sandbar (*Pervaja Koshka*) on the northern coast of Karaga Bay (Fig. 2). At this site, we investigated a cross-section of a pit dwelling that was slowly eroded by ocean waves. This residence is assumed to have been the central one among the three pit dwellings, as reported in the general survey by Ponomarenko (1999). The Karaga 10 and 13 sites are both fortresses (altitude is approximately 10–16 m) located on terraces along the southern coast of Karaga Bay (Fig. 2). At the Karaga 10

Figure 2 Topographical features around Karaga Bay

site, nine pit dwellings have been found by Ponomarenko's general survey (1999). We excavated a cross-section of dwelling "No.4," which is exposed on a cliff due to natural abrasive action. The plan view of this residence is estimated to be circular, and the diameter is approximately 13 m (Ponomarenko 1999). At the Karaga 13 site (Fig. 2), one residence can be found on the surface (Ponomarenko 1999). However, although part of this residence moved downward by approximately 70 cm (due to natural abrasion), artifacts were still obtained by excavating this body of buried soil of the residence.

Accelerator mass spectrometry (AMS) radiocarbon dating demonstrated that the Karaga 6 site was from the 11th to 13th centuries C.E., and the Karaga 10 and 13 sites were from the 15th to 17th centuries C.E. (Takase 2014). The latter sites contained not only Kavran type pottery, but also Ivashka type pottery. Note that since numerous animal remains and bone/antler artifacts were also discovered, the processing activities of these organic materials should be considered when the functions of stone tools are examined.

Chipped stone tools from these sites consisted of points, arrowheads, end scrapers, side scrapers, wedging pieces, flakes, retouched flakes, utilized flakes, and a core (Figs. 3 and 4). This

Table 1 Specimens and results of analysis

Specimen #	Figure #	Site	Artifact class	Stone	Use-wear polish	Striation	Estimated usage
1	Fig. 3:7	Karaga 6	End scraper	Calchedony	N/A	N/A	
2	Fig. 3:8	Karaga 6	Retouched flake	Obsidian	N/A	N/A	
3	Fig. 3:4	Karaga 6	Side scraper	Obsidian	N/A	N/A	
4	Fig. 3:3	Karaga 6	End scraper	Obsidian	N/A	N/A	
5	Fig. 3:1	Karaga 6	End scraper	Chert	A, B types	Pararell to the edge	Cutting/sawing of wood
6	Fig. 3:6	Karaga 6	End scraper	Obsidian	N/A	N/A	
7	Fig. 3:2	Karaga 6	Side scraper	Obsidian	N/A	N/A	
8	Fig. 3:5	Karaga 6	Side scraper	Obsidian	N/A	N/A	
9	Fig. 3:13	Karaga 10	Utilized flake	Obsidian	E2-like type	Unknown	Scraping/whittling hide?
10	Fig. 3:10	Karaga 10	Arrowhead	Obsidian	N/A	N/A	
11	Fig. 3:9	Karaga 10	Arrowhead	Obsidian	N/A	N/A	
12	Fig. 3:14	Karaga 10	Side scraper	Mudstone	B type	Perpendicular to the edge	Scraping/whittling wood
13	Fig. 3:16	Karaga 10	Polished knife	Slate	N/A	N/A	
14	Fig. 3:15	Karaga 10	Polished knife	Slate	N/A	N/A	
15	Fig. 3:12	Karaga 10	Polished knife	Slate	N/A	N/A	
16	Fig. 3:11	Karaga 10	Retouched flake	Basalt	E2 type	Perpendicular to the edge	Scraping/whittling hide
17	Fig. 4:7	Karaga 13	Utilized flake	Obsidian	N/A	N/A	
18	Fig. 4:9	Karaga 13	Utilized flake	Obsidian	E2 type	Perpendicular to the edge	Scraping/whittling hide
19	Fig. 4:1	Karaga 13	Point	Obsidian	N/A	N/A	
20	Fig. 4:3	Karaga 13	Arrowhead	Obsidian	N/A	N/A	
21	Fig. 4:2	Karaga 13	Point	Obsidian	N/A	N/A	
22	Fig. 4:8	Karaga 13	Retouched flake	Obsidian	N/A	N/A	
23	Fig. 4:11	Karaga 13	Side scraper	Obsidian	N/A	N/A	
24	Fig. 4:10	Karaga 13	Side scraper	Obsidian	N/A	N/A	
25	Fig. 4:5	Karaga 13	End scraper	Obsidian	N/A	N/A	
26	Fig. 4:4	Karaga 13	End scraper	Chert	A, B and E2 types	Perpendicular to the edge	Scraping hide and wood
27	Fig. 4:6	Karaga 13	End scraper	Obsidian	N/A	N/A	

study focuses on all the chipped stone tools except for the wedging pieces, flakes, and the core. As shown in Table 1, obsidian was the most common stone for making chipped stone tools, while chert, chalcedony, and basalt were minor materials used to form such tools. Although there were sinkers and hummers created by pecking, stone knives were the only ground stone tools among pebble stone implements at the sites. This study examines the use-wear of these polished stone knives as well as that of the chipped stone tools.

2. Methods

1) Use-wear analysis

In this study, the high-power approach of the lithic use-wear analysis pioneered by Keeley (1977, 1980) was applied. A metallurgical microscope with incident light (Olympus BX-FM) and a magnifier ranging from 100x to 500x was employed for the microscopic observations. Photomicrographs were taken using a digital camera (Olympus DP-21) mounted on the microscope. Before making the microscopic observations, fat on the surface of the artifacts was removed using laboratory paper laced with ethanol.

Pattern recognition of use-wear polish based on microwear morphology was referred to by the classification system established by Keeley (1977, 1980), Kajiwara and Akoshima (1981), Vaughn (1985), and Akoshima (1989). Although these use experiments focused on stone tools made of sedimentary rocks, such as flint and shale, it is applicable to specific types of volcanic rock as well as other sedimentary rocks (e.g., Midoshima 1988). However, since obsidian includes a characteristic mirror-like surface appearance, it is difficult to classify use-wear polish based on the same criteria as other rocks. Thus, based on use experiments by Midoshima (1986), the present study

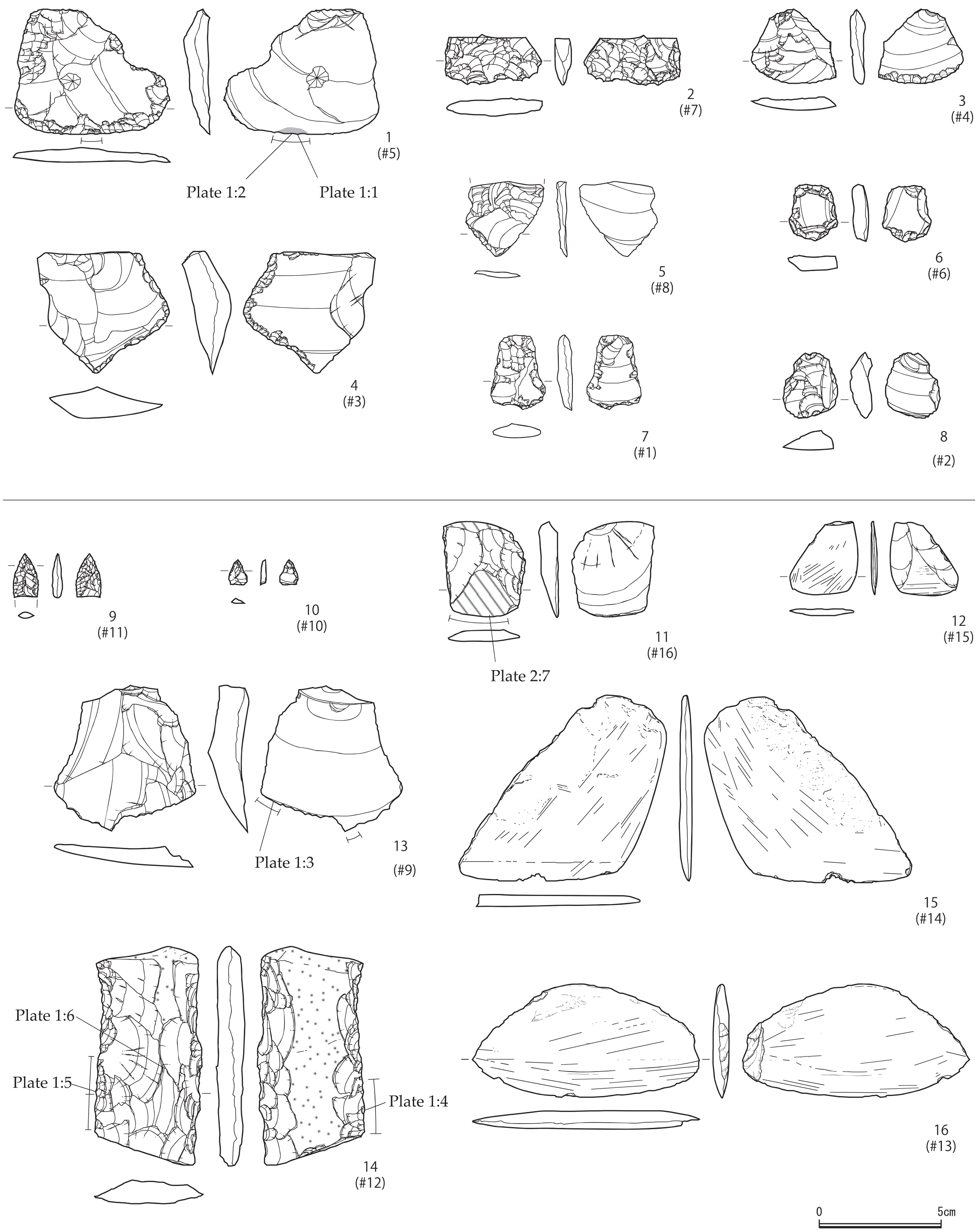


Figure 3 Chipped and ground stone tools from the Karaga 6 (1–8) and Karaga 10 (9–16) sites

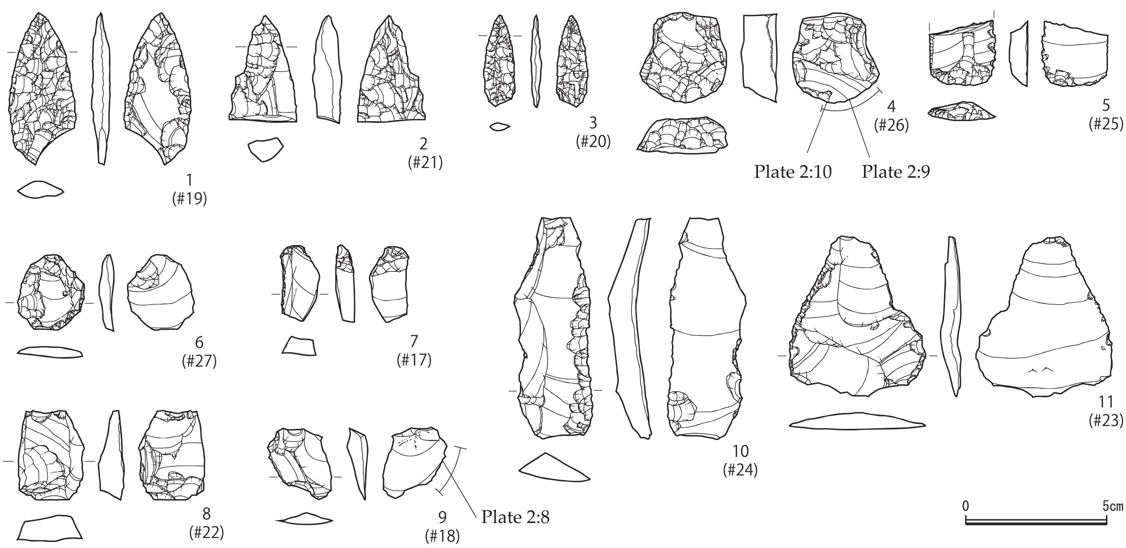


Figure 4 Chipped stone tools from the Karaga 13 site

employs a classification system of use-wear polish specially established for obsidian tools, which is macroscopically consistent with Hurcombe's (1992) experiments.

2) Estimation of the direction of tool movement

The direction of tool movement regarding stone implements for hide tanning was analyzed using a method developed by Takase (2010). First, stone tools with heavy edge abrasions visible to the unaided eye were selected. Then, to ensure that they were used for hide working, "dry-hide polish" (Keeley 1980, Vaughn 1985) or "E2 type polish" (Kajiwara and Akoshima 1981) was determined through use-wear analysis. Next, the use angle, which includes a close relationship with tool inclination, was measured using the replication method (Fig. 5). After the working edges of the specimens were replicated with silicone rubber impression materials, the replicas were vertically sliced with a razor blade to measure the use angle. To slice the replicas precisely for measurement, a dot was made with a soft graphite pencil (e.g., 9B) on a minute tip of the working edge on the ventral face that include the most severe abrasions. This point, created by the graphite particles, was then copied on the inside of the replicas after which it served as the mark to cut. The use angle was measured under a stereoscope, and the graphite particles that remained on the stone tools were easily removed with a kneaded eraser. This method did not damage the stone tools made of fine rock such as obsidian. In the case of coarse textured stone, a mold lubricant (e.g., 5 wt% Paraloid B72 acetone fluid) protected the specimens' surface. Instead of silicone rubber impression materials, using a plastic mold agent that softens in hot water was also effective for various stones such as coarse rocks. In this study, this type of mold agent was used to create a replica of a retouched flake.

If the use angle and edge angle (measured by a protractor) are known, then the direction of tool movement for a tanning tool can be estimated using an interpretative model based on ethnographic data. According to the horizontal axis of Fig. 6, which shows the index of tool inclination, if the given value of this index is smaller than 1.0, then the scraper was used in a

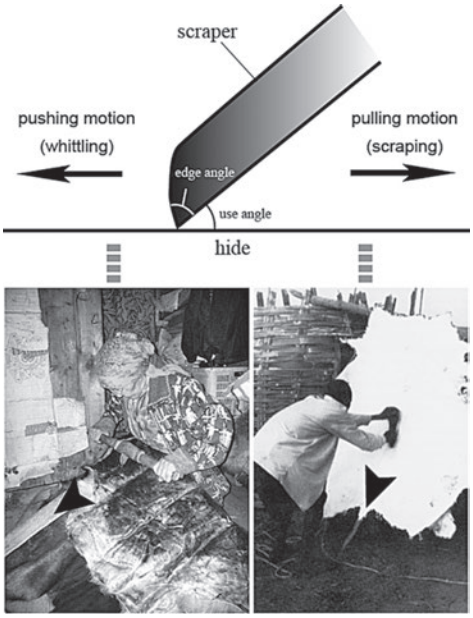


Figure 5 Edge angle, use angle, and the direction of tool movement of end scraper (Takase 2010, Clark and Kurashina 1981)

pushing motion. Conversely, if the index value is larger than 1.0, then the scraper was used in a scraping motion.

3. Results

1) Use-wear analysis

According to the microscopic observations, all the stone tools (except for the side scraper mentioned below) were in mint condition, thus indicating that sediments covered the tools relatively quickly. Table 1 shows the results of the analysis in which use-wear polish was detected on six out of the 27 artifacts.

End scrapers—a major tool type of chipped stone tools used in the Karaga Bay region—exhibited use-wear polish on two out of seven specimens. Both specimens included commonly shiny, smooth, and rounded use-wear polish along their working edges (Plates 1:1, 2, and 2:9). Polish morphology indicated that they definitely correspond to "A and B types" (Kajiwara and Akoshima 1981), "corn/sickle-gloss," "wood polish," "plant polish," and "reed polish" (Keeley 1980, Vaughn 1985). The relatively wide distribution area of use-wear polish also supports this recognition. The direction of the striations is parallel to the edge on one specimen (Plate 1:1 and 2), whereas the other includes striations that are perpendicular to the edge (Plate 2:9). Note that an end scraper displayed other types of use-wear polish with coarse and rounded surfaces covered by striations that were perpendicular to the edge (Plate 2:10). This use-wear polish was classified as a "dry-hide polish" or "E2 type polish," which is occasionally generated when processing dry hides.

Among the six side scrapers, distinct traces of use were only found on one specimen. This

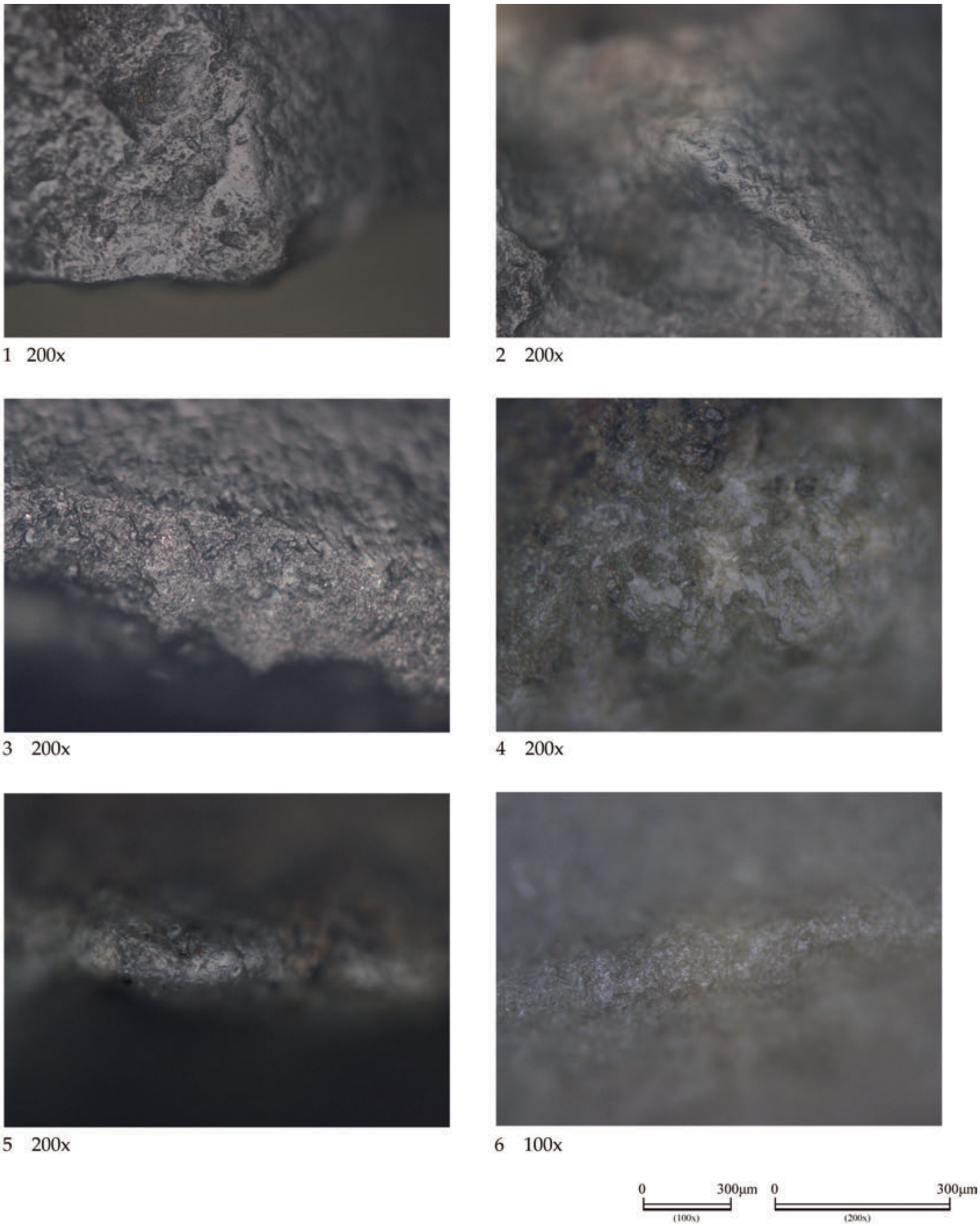
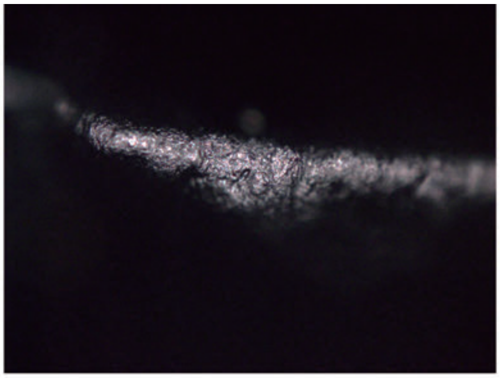


Plate 1 Photomicrographs of stone tools (1)

specimen included smooth use-wear polish with a rounded cross-section along the edge (Plate 1: 4 and 5), although its surface might have been weathered to some extent. The direction of the striations is perpendicular to the edge, and in the central part of this specimen, we found a ridgeline with severe abrasions (Plate 1:6) but no use-wear polish.

7 200x



8 200x

9 200x

10 200x

0 300μm (200x)

Plate 2 Photomicrographs of stone tools (2)

Dry-hide polish or E2 type polish (or E2-like polish) was also found on two out of the three utilized flakes. Among them, one specimen included striations that were perpendicular to the edge (Plate 2:8), although distinct striations could not be recognized on the other specimen (Plate 1:3). Retouched flakes had a similar tendency in which dry-hide or E2 type polish could be seen on one specimen out of the three utilized flakes. We also found striations that were perpendicular to the edge (Plate 2:7). Finally, no arrowheads, points, or polished knives exhibited use-wear polish and striations.

2) Use-angle of tanning tool

Due to the scarcity of stone tools with heavy edge abrasions, this analysis is only applicable to one retouched flake from the Karaga 10 site (#16, Fig. 3:11). Plate 3 shows a cross-section of a replica (sliced vertically) in which its use angle is between 69° and 79°.

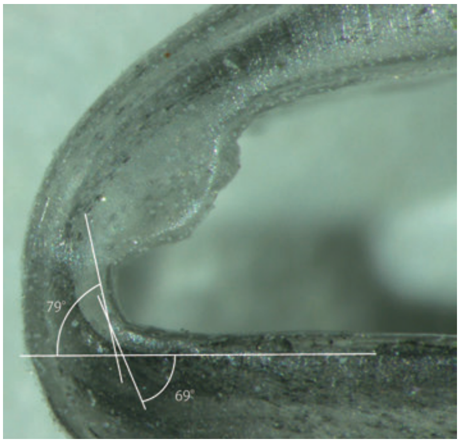


Plate 3 Use angle of a retouched flake (#16) from the Karaga 10 site

4. Discussion

1) Estimated use of stone tools

The results of lithic use-wear analysis reveal that the A, B, and E2 types of use-wear polish were distributed on the edges of the end scrapers. Since the former two types had a high correlation with plant working, it was estimated that the specimens with these types of use-wear polish (#5 and #26) were used for processing plants. The restricted distribution area of the use-wear polish indicated that the worked material was relatively hard (such as wood) and not soft (such as grass). The direction of the striations suggests that they were both used in cutting/sawing and scraping/whittling motions. In addition to the A and B types, one end scraper from the Karaga 13 site (#26) exhibited E2 type on its edge, although it was not necessarily well developed. Since the direction of the striations of this specimen is perpendicular to the edge, this end scraper was also used for dry hide tanning. Thus, it can be concluded that end scrapers were tools used for both wood working and hide processing. However, it is important to note that since weakly developed patches of E2 type polish were detected, this indicates that end scrapers were not necessarily the main tool used for hide tanning.

In contrast, retouched and utilized flakes (#9, #16, and #18) included well-developed E2 type polish on their edges, thus suggesting that they were mainly used for hide working. Morphological features of use-wear polish and striations of one side scraper (#12) demonstrated that it was used for plant working, especially scraping/whittling plants. Furthermore, ridge abrasions in the central part of the tool indicated that this tool was clearly hafted. The function of the arrowheads, points, and stone knives could not be specified due to the lack of polish. The analysis of macro-scale breakage is more effective for estimating use of projectile points in this region. Although stone knives were probably used for processing soft materials, such as meat, we must focus attention on the extinction of use-wear polish due to repolishing. Given that there was weak polish on the stone knives, this estimation should be verified in the future studies.

According to the result of the lithic use-wear analysis, there was no tool for making bone/antler implements among the lithic assemblage. Currently, we have to consider that they were

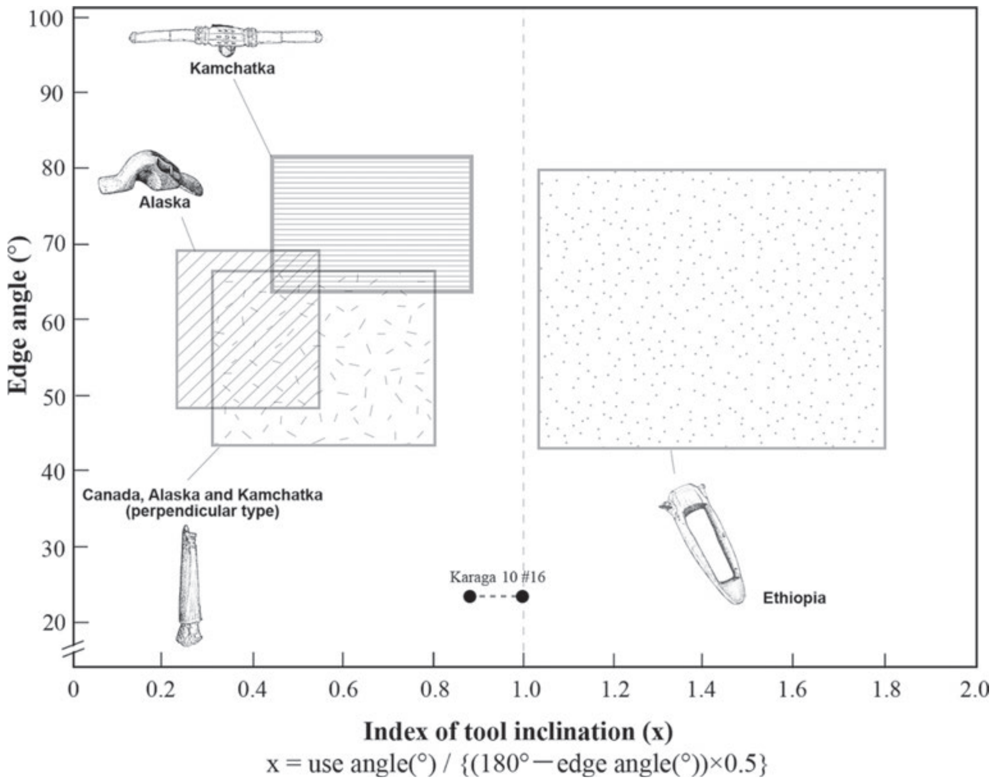


Figure 6 Estimation of the direction of tool movement from the Karaga 10 site

made with iron tools, not with stone tools. Although no metal tools were restored in our excavations, some indirect evidences (e.g., cutting and planning marks by metal tools) can be found on the surface of wooden artifacts, especially on one wooden bow element (Takase 2014). Considering the distribution of iron tools along the coast of the Circum-Okhotsk Sea in the second millennium C.E., the possibility that bone/antler implements were primarily made by metal tools along Karaga Bay is highly probable.

2) Direction of tool movement and implications for scraper history

Fig. 6 presents the results of the analysis for estimating the direction of tool movement. A retouched flake (#16, Fig. 3:11) was estimated to have been used in a pushing motion, since the index value of tool inclination was less than 1.0. At the same time, it is notable that the edge angle of this artifact is small (approximately 25°), which indicates that it was not a stone edge of a Paleo-Asiatic type scraper since the angles of such a scraper normally range from 60° to 85°. Thus, this artifact is estimated to have been held by hand or hafted into other type of handle, even if it was used in a pushing motion.

The results of the lithic use-wear analysis also suggest that utilized or retouched flakes, not end scrapers, were the main tools for hide working from the 11th to 17th centuries in Northeastern Kamchatka. This finding leads to the understanding that the Paleo-Asiatic type scraper was developed specifically in the west coast of the peninsula (e.g., the coast of Penzhina Bay), not in the east, before the 17th century.

According to the ethnographic documents of Northeastern Asia after the end of the 17th century, non-Tungustic peoples processed animal hides with the Paleo-Asiatic type scraper that was solely used in a pushing motion. From archaeological sites of the Old Koryak culture (5th to the 17th centuries C.E.), we can find the prototype of this scraper in which its handle was made from the ribs of sea mammals. Hence, the occurrence of this type of scraper dates back before the 17th century. However, end scrapers from the Old Koryak culture period were used in both pushing and pulling motions, which indicates that the variety of hide processing tools was wider than the ethnographic era among which the Paleo-Asiatic type scraper was one such tool. Conversely, at a particular point of time during the Old Koryak culture period, the Paleo-Asiatic type scraper had become the only tool for hide tanning, as ethnographic documents demonstrate. Even though it is still difficult to specify the location of this scraper's origin, we believe that a wide area from the Chukchi Peninsula to the northern coast of the Okhotsk Sea (including Northern Kamchatka) is a strong candidate for consideration (Takase 2012).

Based on the results of this study, it is possible to exclude the Karaga Bay region as the possible area for the origin of the Paleo-Asiatic type scraper, since the end scraper was not the main tool used for hide working from the 11th to 17 the centuries. However, numerous large and rounded end scrapers were found in the Old Koryak culture sites along the coast of Penzhina Bay in Northwestern Kamchatka. Therefore, this area is still a strong candidate as the homeland of the Paleo-Asiatic type scraper.

Studies over the last fifteen years have revealed that the sequence of archaeological artifacts in Northeastern Kamchatka includes unique characteristics (Ponomarenko1999, 2012, Takase 2013). In this region, Kavran type pottery became diffused from the west coast of the peninsula around the 11th century and produced until the 17th century. In addition, Ivashka type pottery emerged around the 13th century in the Ivashka, Sukhaya, and Dranka River basins. From the 15th to 17th centuries, the distribution area of this type of pottery expanded to the coast of Karaga Bay, which is approximately 50 km north of where Ivashka type pottery was used from the 13th to 15th centuries (Takase 2014). Furthermore, other types of clay vessels, such as pottery with clay rope ornaments and grid-work impressions, can also be found from the 15th to 17th centuries. Such dynamics of these artifacts indicate that the east coast of Northern Kamchatka includes a different history from that of the west coast, although cultural contacts can be seen between both areas to some extent. Therefore, it is not surprising to see a significant difference in the tools used for hide processing between the western and eastern coasts of the Kamchatka Peninsula. In pursuit of the origin of the Paleo-Asiatic type scraper, future studies should focus on stone scrapers from Penzhina Bay in the Kamchatka Peninsula.

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Note

1) This obsidian artifact was excavated at the Karaga 6 site. In the previous paper (Takase 2014), the author reported it in both in Figures 5 and 10. However, it should be pictured only in Figure 5; here, I correct the error. No change is needed in total number of artifact from each site (Table 1 in Takase 2014).

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