A use-wear analysis of the Late Glacial Microblade assemblage from Hokkaido, Northern Japan: A case study based on the Yoshiizawa site

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ABSTRACT

Topics currently debated in the Upper Palaeolithic (UP) research on Hokkaido, northern Japan, include how to explain behavioral and natural processes that form and affect variability in lithic technologies and stone tool assemblages. The study of stone tool functionality helps in understanding the meaning of variability in stone toolkits. We performed a use-wear analysis on a late Microblade assemblage from the Yoshiizawa site, northeastern Hokkaido. Of 22,265 specimens, we selected 160 samples from two lithic concentrations (BL2A and BL2B) that mainly comprise formal tools; microblades, a stemmed point, bifaces, end scrapers, burins, burin spalls, side scrapers, drills, blades, and an edge-ground axe. The main findings revealed that: traces from working on hides can be observed on the distal and lateral edges of end scrapers; the facet edges of burins and burin spalls show traces resulting from antler, bone, ivory, and hide processing; blades were used for sawing or cutting hides. Similar results, in terms of patterns of functional relationship, have been observed on toolkits from other concentrations in Yoshiizawa, namely the BL1 and BL3. The results indicate that each stone tool was roughly correlated with a small number of specific functions, rather than serving as a multifunctional tool. UP foragers may have honed lithic technologies towards the production of relatively specialised tools to adapt to the Late Glacial environments of the Palaeo-Sakhalin/Hokkaido/Kurile Peninsula.

KEYWORDS: Late Glacial, Hokkaido, use-wear analysis, Microblade assemblage, Oshorokko-type microblade core

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1. Introduction

Over the last fifty years, numerous archaeological investigations have found more than seven hundred Upper Palaeolithic (UP) sites on the northernmost Japanese island of Hokkaido (Japanese Palaeolithic Research Association 2010). Recent researches based on geochronological and technotypological analyses indicate that the Hokkaido UP assemblages seem to be divided into four groups: Small Flake, Flake, Blade, and Microblade assemblages. Further, it seems that the technological transitions between these assemblages may have roughly corresponded with changes in flora, fauna, and landscapes during the Marine Isotope Stages (MISs) 3 and 2 (e.g., Izuho 2013; Izuho *et al.* 2012; Izuho & Sato 2008; Izuho & Takahashi 2005; Sato 2003; Yamada 2006). During the late MIS3, Small Flake assemblages probably dated to 30,000 ^{14}C BP (hereafter, dates are given in uncalibrated ^{14}C BP except for some cases) seem to have emerged in deciduous broadleaf forests, accompanied with a faunal group, the *Palaeo loxodon-Sinomegaceroides* complex, that comprised warm-adapted animals including Naumann's elephant and Yabe's giant deer. Later, during the Last Glacial Maximum (LGM: 26.5–19 ka), early Microblade, Blade, and Flake assemblages, all dated between 22,000 and 20,000 ^{14}C BP, may have appeared on the sub-arctic taiga in coincidence with patchy grasslands and/or high moors, where the land mammals of Mammoth Fauna including woolly mammoth and steppe bison are also known to have lived. After the LGM, various late Microblade assemblages seem to have emerged coincidently with the fluctuation between coniferous forests and open-forest taiga with grasslands during the Late Glacial (LG), where large-sized mammals of Mammoth Fauna are considered to have gradually disappeared.

Among the assemblages discussed here, the early and late Microblade assemblages show a high standardisation of stone tools, including microblades, burins, end scrapers, and side scrapers. Indeed, differences between the two Microblade assemblages can be seen in the presence of newly invented tools, such as bifacial-stemmed points and edge-ground stone axes, found only from the late Microblade. In addition, the inter- and intra-site variability in stone toolkits became more remarkable in the latter assemblages (Kato 1970; Nakazawa *et al.* 2005; Yamada 2006), which may indicate the occurrence of task-specific occupations and an increase in logistical mobility (Yamada 2006). Technological responses to this change in the direction towards more specialised tools that were designed to undertake a limited range of functions are also postulated to have occurred (e.g. Bousman 1993; Odell 1994; Shott 1986; Torrence 1983, 1989).

Researches on the Hokkaido UP have long focused primarily on chronological studies based on typological features of lithic assemblages. However, although these conventional studies have a meaningful role to play in building our understanding of cultural sequences, additional work is now required to explore how behavioral and natural processes formed and affected the composition and variation of stone tool assemblages (e.g. Izuho *et al.* 2012; Nakazawa *et al.* 2005, 2009; Sato 1992; Yamada 2006). In relation to these issues, studies of stone tool functionality will provide further clues to enable us to understand the meanings inherent in the variability of stone toolkits. Thus, as a case study, we report on a use-wear analysis in this paper that examined the functions of stone tools in a late Microblade assemblage from the Yoshiizawa site, northeastern Hokkaido (Sato & Yamada 2014). Our study builds on previous works in which we have presented results of analyses on two lithic concentrations from this site (Iwase 2014; Iwase *et al.* 2016). With this in mind, the present study focuses especially on other concentrations to reveal the similarities and/or differences in stone tool usages.

2. Late Glacial Hokkaido: Geography, flora, and fauna

Japan is comprised of a long chain of islands situated between 45°N and 24°N along the northwestern Pacific Rim. The biggest of these islands are Hokkaido, Honshu, Shikoku, Kyushu, and Ryukyu; with the Sea of Japan to the west, this archipelago stretches parallel to the main Asian continent. Hokkaido is located in the northernmost part of the archipelago, lying between 41°24′–45°30′N and 139°20′–145°48′E (Figure 1).

As a result of global glacioeustatic sea level drop, Hokkaido seems to have been connected with Sakhalin and the main Asian continent around the mouth of the Amur River during the late Late Pleistocene (late MIS3 and MIS2, roughly 50,000–10,000 BP) (Ono 1990). This geographical district is called Palaeo-Sakhalin/Hokkaido/Kurile (SHK) Peninsula (Sato 2003). In addition, Palaeo-Honshu Island was formed by a combination of Honshu, Shikoku, and Kyushu (Ota & Yonekura 1987). However, a land bridge may not have emerged in the Tsugaru Strait between Hokkaido and Honshu during the late Late Pleistocene (Ono 1990).

Although the LGM vegetation of the southern Palaeo-SHK Peninsula, Hokkaido, has been reconstructed in detail based on several pollen and plant macro fossil records (Igarashi 1996; Igarashi *et al.* 1993, 2002; Ishii *et al.* 1981; Sakaguchi 1989; Suzuki *et al.* 1999), the LG flora is not fully revealed (Igarashi 1990; Igarashi *et al.* 1993). The LGM vegetation seems to have consisted of four types of taiga from north-to-south, as follows; (1) Open larch-pine taiga; (2) Open larch-pine-spruce taiga; (3) Open larch-pine-spruce-fir taiga; and (4) Open spruce-larch-fir-oak taiga (Igarashi 2008; Izuho 2013). In each group, the prevalence of non-arboreal taxa with a composition that resembled those of Siberia implies that the mammoth-steppe may have expanded onto this peninsula. Indeed, after the LGM, grasslands gradually started to decrease as coniferous forests

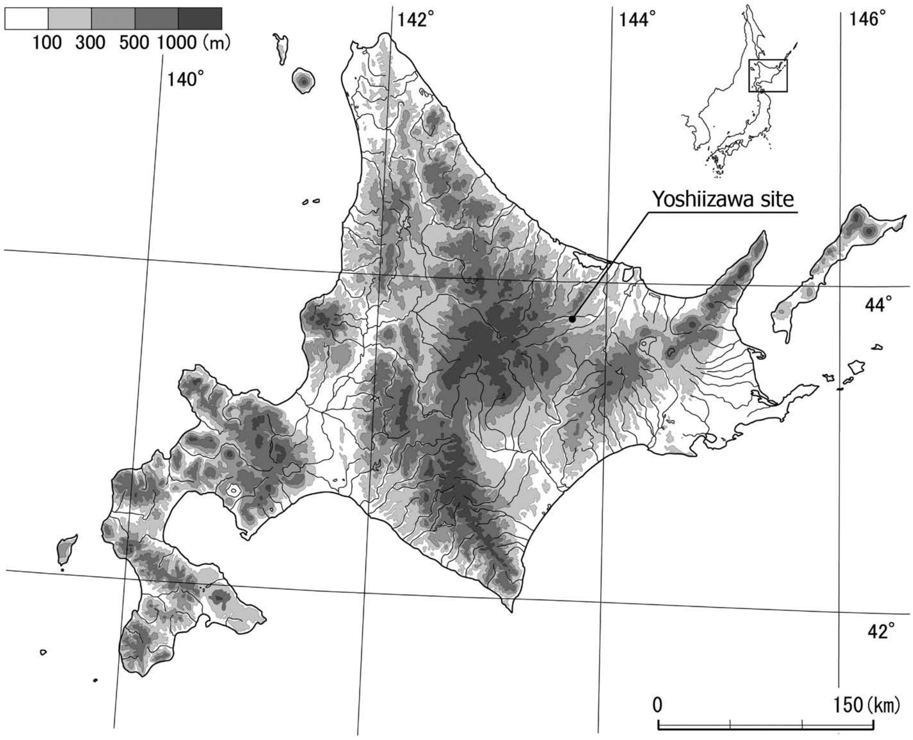

Figure 1. Map of Hokkaido and the Yoshiizawa site (after Izuho et al. 2012)

including *Quercus* and *Fagus* spread. However, pollen records around the YD cold reversal that are dated to 12,900–11,600 Cal BP (11,000–10,000 BP), suggest that open taiga comprising larch, pine, spruce, and fir coexisting with grasslands expanded again on the Palaeo-SHK Peninsula (e.g., Igarashi 2008; Izuho 2008; Kawamura & Kito 2000; Takiya & Hagiwara 1997). This means that the LG vegetation seems to have fluctuated remarkably between coniferous forests and open-forest taiga with grasslands.

The southern Palaeo-SHK Peninsula, Hokkaido, has so far yielded just a few fossils of faunal remains including Naumann's elephant, Yabe's giant deer, woolly mammoth, and steppe bison. However, not all of these remains have been recovered from archaeological sites. The former two species were directly dated between 49,000 and 30,000 ^{14}C BP, while the latter two between 45,000 and 18,000 ^{14}C BP (Iwase *et al.*, 2012, 2015; Takahashi 2007; Takahashi & Izuho, 2012). This means that Hokkaido actually lacks sufficient records to reconstruct the LG fauna. Mammoths and bison may have gone extinct or migrated to the northwards after the LGM, when the climate started to ameliorate and the open-forest taiga with grassy plains began to gradually decrease on Hokkaido (Igarashi 1993; Igarashi & Kumano 1981; Igarashi *et al.* 1993; Iwase *et al.*, 2012, 2015; Takahashi 2007). This certainly implies the possibility that the LG terrestrial mammals may also show the transition into the Holocene faunal groups, probably comprising mainly medium to small-sized animals (Yamada 2006).

3. Materials and methods

(1) Site

The Yoshiizawa site is an open-air site located in the Kitami Basin, northeastern Hokkaido (N43°47′, E143°41′) (Koaze *et al.* 2003). The site is situated on the southern terrace of the Muka River, a branch of the largest river, the Tokoro, in this region, and is at an altitude of *ca.* 170 m a.s.l. (Figure 1). At this site, the artefact-bearing layer was located in the upper part of an aeolian loam, 0.2–0.4 metres below the surface (Sato & Yamada 2014). Palaeolithic artefacts were recovered from several block excavations. From a total of 22,265 lithic specimens, 21,598 artifacts were found in three-to-four lithic concentrations, 15–20 metres distant from each other, named BL1, BL2A, BL2B, and BL3 (Figure 2; Table 1). Excavations of all concentrations, excluding the BL2B, are almost completed (Sato & Yamada 2014). Although a preliminary analysis revealed

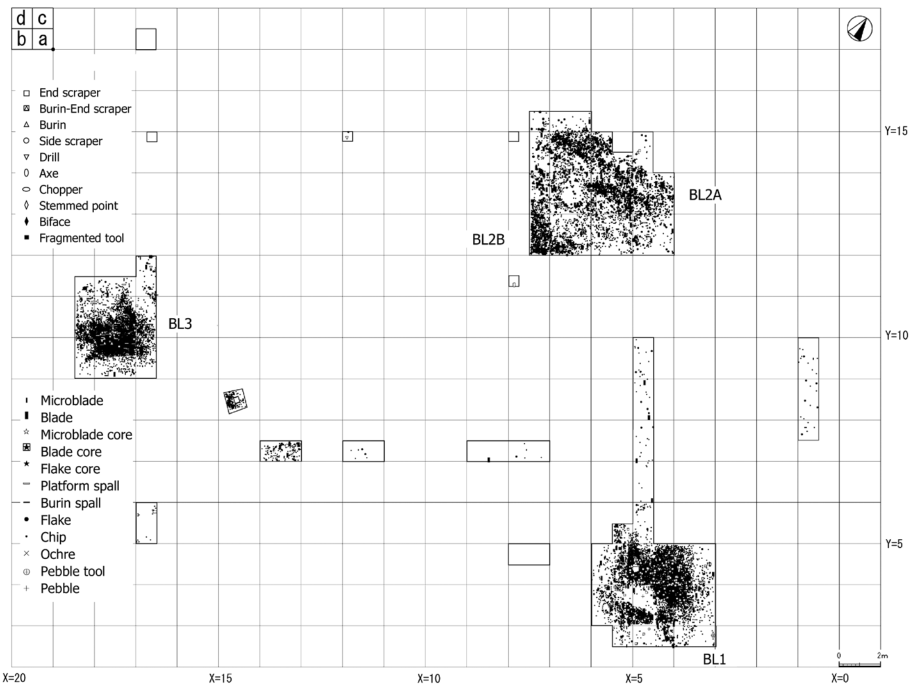

Figure 2. Distribution of lithic concentrations from Yoshiizawa (after Sato and Yamada 2014)

Table 1. Lithics from the late Microblade assemblage of Yoshiizawa

	MB	MB Core	PF Spall	ST Point	Biface	ES	BU	BU Spall	BU-ES	SS	DR	BL	FL/CH	BL/FL Core	Axe	Ochre	Others	Total
BL1	54		2		6	130	12	40		32	2	113	8363	1		1	46	8802
BL2A	12	1	1	1	2	31	7	26		4	3	87	3687	2	1		8	3873
BL2B	7				1	11	3	21		1		17	1070			7	11	1149
BL3	140	7	27		6	48	30	182	2	6	7	72	7180	1		26	40	7774
Out-of-LC	2		1			2	2	6		1	1	16	607		1		28	667
Total	215	8	31	1	15	222	54	275	2	44	13	305	20907	4	2	34	133	22265

MB, microblade; PF, platform; ST, stemmed; ES, end scraper; BU, burin; SS, side scraper; DR, drill; BL, blade; FL, flake; CH, chip

that there are only a few refitted specimens that connect all four concentrations, formal stone tools including microblades, microblade cores, burins, and end scrapers from each concentration show similar technotypological features, and indicate that the site represents a single component of a Microblade assemblage (Sato & Yamada 2014). In particular, microblade cores exhibit the reduction method seen in the Oshorokko-type, one of the typical microblade cores from late Microblade assemblages that involves preparing relatively small bifaces as blanks and forming platforms by the removal of short spalls (Nakazawa *et al.* 2005). In Yoshiizawa, two charcoal samples gave radiocarbon dates of 17,460±70 ^{14}C BP (TKa-14438) and 15,040±60 ^{14}C BP (TKa-14440) (Kunikita *et al.* 2014), although their relationship to the lithic concentrations remains unclear. Another Oshorokko-type microblade assemblage from the Ozora site, in eastern Hokkaido, was found in an aeolian loam below the Tarumae-D tephra (Ta-d, 7,000 ^{14}C BP) and above the Eniwa-a tephra (En-a, 17,000 ^{14}C BP) (Izuho *et al.* 2012; Izuho & Akai 2005), which indicates that this type of Microblade assemblage may have emerged after the LGM, possibly during the LG period (Yamada 2006).

The lithic assemblages from Yoshiizawa comprise microblades, Oshorokko-type microblade cores, platform spalls, a bifacial-stemmed point, bifaces, edge-ground axes, end scrapers, side scrapers, burins, burin spalls, burin-end scrapers, drills, blades, flakes, blade cores, and flake cores (Figure 3). In addition, other material includes pebble tools and non-utilitarian artefacts (ochre) (Table 1). Lithic raw materials mainly consist of obsidian, followed by small amounts of ‘hard-shale’ (a type of sedimentary rock similar to flint and chert), andesite, tuff, and sandstone (Table 2). Primary reduction includes the production of blades and microblades, and bifacial thinning. Continuous lateral retouches of side scrapers, end scraper edging on the distal ends of blades, and burin faceting were secondary reduction strategies.

As discussed by Yamada (2014, pp. 283–285), four lithic concentrations from Yoshiizawa show the variability in the composition of lithic assemblages (Table 2).

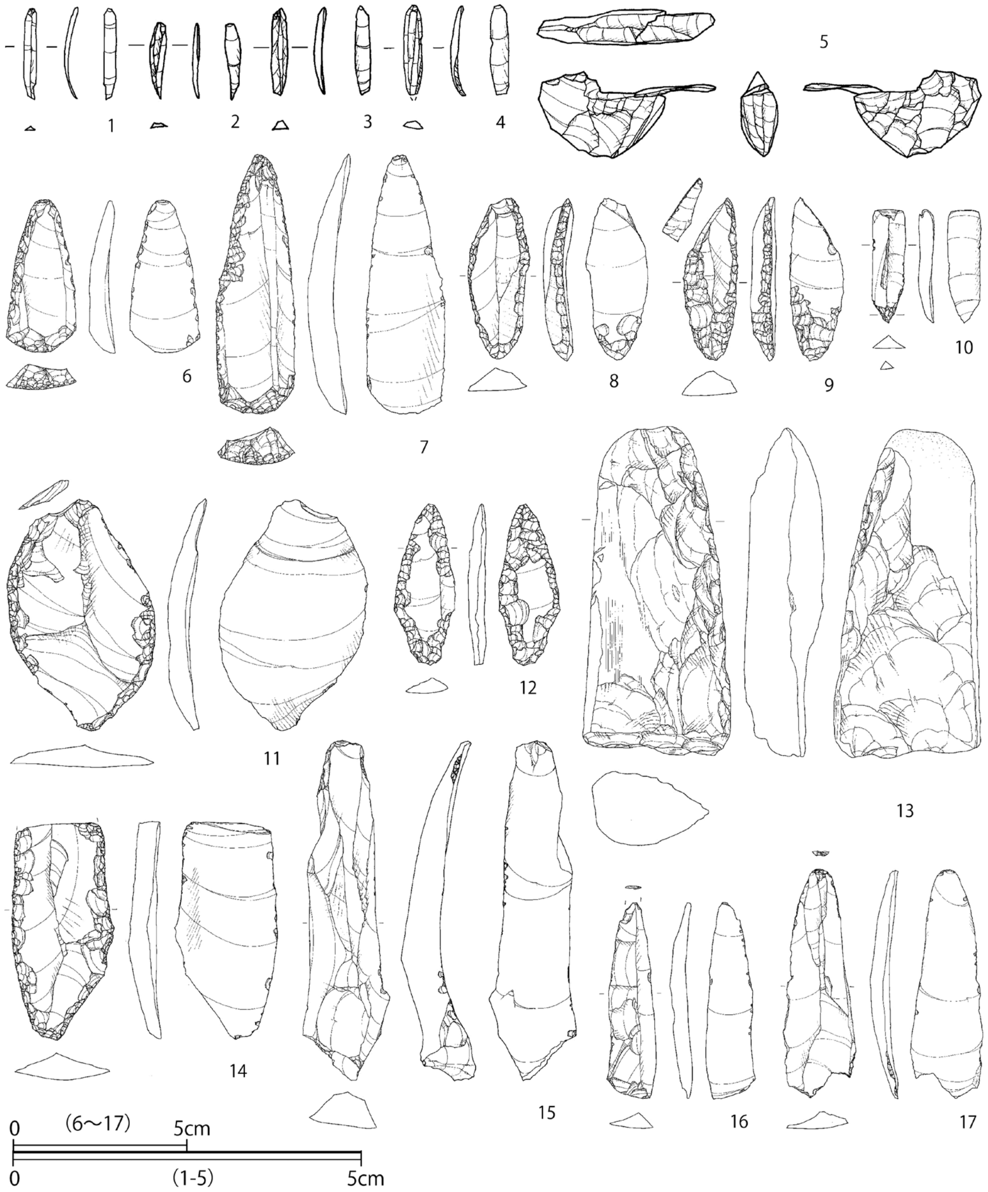

Figure 3. Stone tools of the late Microblade assemblage from Yoshiizawa (after Sato and Yamada 2014). 1–4, microblades; 5, refitted specimens including Oshorokko-type microblade core and platform spall; 6–7, end scrapers; 8–9, burins; 10, drill; 11, 14, side scrapers; 12, stemmed point; 13, edge-ground axe; 15–17, blades

Table 2. Lithic raw materials from Yoshiizawa

	Obsidian	Hard-Shale	Andesite	Tuff	Sandstone	Others	Total
BL1	8691	73	28	2	3	5	8802
BL2A	3499	367	2	5			3873
BL2B	1072	59	5	5		8	1149
BL3	7476	242	17	13		26	7774
Total	20738	741	52	25	3	39	21598

Of these, the BL1 and BL3, for example, are mainly composed of chips smaller than 2 cm, probably produced by retouches on formal tools, bifacial thinning, and blade core preparations. In addition, at the BL2A, there is a relatively higher frequency of flakes (>2 cm) and blades than at the BL1 and BL3, implying flake and blade production from flake and blade cores and bifaces in the earlier stages of their reduction. Furthermore, each lithic concentration shows a remarkable variability in stone toolkits (Table 2); for instance, BL1 incorporates a higher frequency of end scrapers and side scrapers, while edge-ground axes and a bifacial-stemmed point are found only at BL2A. In contrast, the BL3 concentration has the highest frequency of microblades, microblade cores, platform spalls, burins, and burin spalls.

(2) Materials

Of a total of 21,598 artefacts from four lithic concentrations, Iwase (2014) and Iwase *et al.* (2016) analysed 454 specimens recovered from the BL1 and BL3 concentrations. In this paper, we focus especially on the artefacts from BL2A and BL2B (Table 1). Out of 5022 artefacts from these two concentrations, almost all, excluding the debitage (flakes and chips), pebble tools, and non-utilitarian artefacts, were scanned and a total of 160 specimens were sampled for use-wear analysis. Accordingly, the specimens were not selected at random, as the focus of this analysis is mainly directed towards formal tools. The selected specimens include microblades (N=18), a platform spall (N=1), a stemmed point (N=1), bifaces (N=2), end scrapers (N=35), burins (N=7), burin spalls (N=43), side scrapers (N=3), drills (N=2), blades (N=25), flakes (N=19), an edge-ground axe (N=1), and other informal retouched tools (N=3) (Table 3). These artefacts account for just 3.2% (N=160/5022) of the total number from BL2A and BL2B, but 60.4% (N=160/265) of all formal artefacts excluding flakes and chips.

The raw material of specimens for analysis mainly comprises obsidian (86.3%, N=138), followed by small amounts of high quality hard-shale (13.1%, N=21) and tuff (0.6%, N=1). The surfaces of lithic artefacts from Yoshiizawa are generally in good

Table 3. Lithics selected for use-wear analysis from the BL2A and BL2B

		MB	MB Core	PFS pall	ST Point	Biface	ES	BU	BU Spall	SS	DR	BL	FL/CH	BL/FL Core	Axe	Others	Total
BL2A	Recovered	12	1	1	1	2	31	7	26	4	3	87	3687	2	1	8	3873
	Analyzed	11		1	1	2	25	5	25	2	2	24	16		1	1	116
	Use-wear						12	4	4			2					22
	%	0.0		0.0	0.0	0.0	48.0	80.0	16.0	0.0	0.0	8.3	0.0		0.0	0.0	19.0
BL2B	Recovered	7				1	11	3	21	1		17	1070			18	1149
	Analyzed	7					10	2	18	1		1	3			2	44
	Use-wear						1	2	1								4
	%	0.0				0.0	10.0	100	5.6	0.0		0.0	0.0			0.0	9.1
Total	Recovered	19	1	1	1	3	42	10	47	5	3	104	4757	2	1	26	5022
	Analyzed	18		1	1	2	35	7	43	3	2	25	19		1	3	160
	Use-wear						13	6	5			2					26
	%	0.0		0.0	0.0	0.0	37.1	85.7	11.6	0.0	0.0	8.0	0.0		0.0	0.0	16.3

MB, microblade; PF, platform; ST, stemmed; ES, end scraper; BU, burin; SS, side scraper; DR, drill; BL, blade; FL, flake; CH, chip
Others includes: infromal tetouched tools, pebble tools, ochre, pebble

condition and thus allow for the observation of traces, with some exceptions.

(3) Methods

1) Macroscopic fractures

Numerous experimental studies with the projectile stone tools have revealed distinct patterns of impact damage (e.g., Barton & Bergman 1982; Bergman & Newcomer 1983; Fischer *et al.* 1984; Midoshima 1991, 1996; Moss & Newcomer 1982; Odell & Cowan 1986; Sano 2009; Sano & Oba 2015). Experiments have mainly focused on the bifacial and backed points mounted on the tips of spears, darts, and arrows. In particular, experimental analyses on projectile impacts and accidental fractures from blade productions, retouches, and trampling (Fischer *et al.* 1984; Sano 2009) have revealed that flute-like, burin-like, bifacial spin-off, and unifacial spin-off fractures longer than 6 mm cannot be produced by accidental causes other than uses as projectile tips.

In contrast, relatively little attention has been paid to the fracture patterns occurring on microblades, the small lithic elements which are generally considered as insertions into osseous implements as lateral blades. Recently, Yaroshevich *et al.* (2010) and Pétillon *et al.* (2011) presented results of pilot experiments with rectanglar microliths and backed bladelets attached as lateral blades into composite hunting weapons. Their results indicated that several types of impact damage occurred on microliths and bladelets; (1) Bending fractures on the sharp lateral edge; (2) Bending fractures that obliquely remove the tip at a blunt angle; (3) Step-terminating bending fractures on the tip, (4) Spin-off fractures that include burin-like impacts, and; (5) Tip-crushing with spin-off fractures. Because all the above impact fractures are very small ranging from 1 mm to 4 mm, further studies are required to reveal their diagnostic patterns on microblades.

Nevertheless, the experimental fractures (1)–(5) that are observed on small lithic elements can be used as clues to explore the use of microblades as projectile inserts.

In this study, following these experimental studies (e.g., Fischer *et al.* 1984; Pétillon *et al.* 2011; Sano 2009; Yaroshevich *et al.* 2010), a stemmed point, bifaces, and microblades were observed using the naked eye, a loupe, and a microscope (at magnifications up to 50x).

2) Microscopic traces

Present-day microscopic use-wear analysts agree that functional analysis of stone tools must be based on a systematic framework of use-wear experiments. A large number of experiments repeatedly indicated that the distribution, direction, and morphology of microchipping, striation, rounding, and micropolish (use-wear polish) can contribute to the interpretation of use-motion and worked material (e.g., Iwase 2015; Kajiwara & Akoshima 1981; Keeley 1980; Midoshima 1986, 1988; Moss 1983; Odell 1981; Sano 2012; Tringham *et al.* 1974; Vaughan 1985a; van Gijn 1990).

On the basis of previous studies, microwear analysis can be divided into two different approaches: 'low power' and 'high power.' Of these, the low power approach employs low magnifications up to 100x and is especially focused on the analysis of microchipping to determine the relative hardness of worked materials and their motions of usage (Akoshima 1981; Midoshima 1982; Odell 1981; Odell & Odell-Vereecken 1980; Tringham *et al.* 1974). In contrast, the high power approach is characterised by the analysis of micropolishes that can be observed at high magnifications over 100x, and that can be used to indicates relationships between polish morphologies and specific worked materials. And it is now accepted that the association is moderate with some overlap rather than a one-to-one correlation (e.g., Kajiwara & Akoshima 1981; Keeley 1980; Midoshima 1986, 1988; Moss 1983; Sano 2012; Vaughan 1985a; van Gijn 1990). Since the integration of two methods (Vaughan 1985a), current microwear studies generally use both approaches to precisely interpret the functions of stone tools.

In this study, microscopic use-wear analysis involved both low power and high power approaches. To observe microwear on lithic surfaces, a metallurgical microscope (Olympus BX-FMS) was used at magnifications ranging from 50x to 500x, and a digital camera (Olympus DP-21) was used for recording all data. In addition, this study follows the previous studies by Kajiwara & Akoshima (1981), Midoshima (1986), and Iwase (2015) as the references for the identification and classification of use-wear polishes on obsidian and hard-shale artefacts. Similar to the flint experiments, various contact materials, including grass, wood, antler, bone, ivory, dry-hide, fresh-hide, flesh, shell, and stone can form distinctive polished appearances, which can also partially overlap with each other, on obsidian and hard-shale.

3) Independent Use Zone

In this study, we count each portion of an artefact that bears a use-wear trace as an ‘independent use zone’ (IUZ: Vaughan 1985a, 1985b). Indeed, according to Vaughan, an IUZ is an edge or ridge that has been used to perform a certain task or function, and can be defined based on a use action, a contact angle of working edge, and a worked material, all of which can be inferred from the use-related traces on a stone tool. For example, if the same portion of a tool has been used for two tasks with different actions, contact angles, or worked materials, then two IUZs can be distinguished. The concept of an IUZ can thus provide a clue to clearly demonstrate relationships between tool types, working edges, use motions, and worked materials.

4. Results

Macro- and microscopic analyses reveal that a total of 26 specimens show use-related traces, while the rest of the samples exhibit no traces or unclear traces. Lithics bearing definite use-related traces comprise end scrapers (*N*=13), burins (*N*=6), burin spalls (*N*=5), and blades (*N*=2) (Tables 3, 4). The use-wear traces were observed on 16.3% of total sample. Out of a total of 26 specimens, working edges and use motions can be estimated from 31 used zones, and worked materials from 12 zones (Tables 5, 6, 7). The main findings from this analysis in terms of each stone tool class are discussed below.

(1) Microblades

Macro- and microscopic analyses reveal that 18 selected microblades overall show no clear use-related traces. However, one microblade has distinctive striations running perpendicularly to its long axis on the midsection of its ventral surface (Figure 4: 1, Photo a). These striations reach from one side to the other, seemingly suggesting that they may have been the result of perpendicular activities, including scraping, whittling, and planing. Yet, the width of the specimen is so narrow (less than 3 mm) that it seems difficult to manipulate by hand. If the microblade had been inserted into an osseous shaft and used for transverse motions, then striations should be limited to the edge, not spread out onto the other side of edge. This implies that the striations may not have been directly produced by use, but rather by non-utilitarian causes.

(2) End scrapers

From a sample of 35 end scrapers, 13 specimens display clear traces (Table 3). A total of 15 zones can be detected for the estimation of working edges and motions used (Tables 5, 6), and four zones can be seen for worked materials (Table 7). The distal end of an end scraper bears well-developed traces that exhibit a dull, pitted, and matt appearance

Table 4. List of lithics bearing the use-wear traces

Fig.	ID	LC	Tool	Raw Material	Edge Angle (°)	Working Edge	Use Motion	Worked Material	Photo	Remarks
4	09930	2A	End scraper	Obsidian	52.5	Lateral edge (left)	C/S	Hide	c	Butchering
					55.3	Lateral edge (right)	C/S	Hide		Butchering
					78.5	End scraper edge	SC/WH			
6	09931	2A	Burin	Obsidian	72.8	Burin facet edge	SC/WH	Hide	e	
					82.4	Platform of burin spall	SC/WH	Hide	f	
	10208	2A	End scraper	Obsidian	84.7	End scraper edge	SC/WH			
	11120	2A	End scraper	Obsidian	78.3	End scraper edge	SC/WH			
	11410	2A	Blade	Obsidian	42.9	Lateral edge	C/S	Hide	l	Butchering
10	12304	2A	Burin spall	Hard-shale	103.2	Burin facet edge	SC/WH	ABI	i	
	13531	2A	Blade	Obsidian	65.4	Lateral edge	C/S			
11	14033	2A	Burin spall	Hard-shale	103.7	Burin facet edge	SC/WH	ABI	j	
5	14155	2A	End scraper	Obsidian	63.0	Lateral edge	C/S	Hide	d	Butchering
8	15483	2A	Burin	Obsidian	107.0	Burin facet edge	SC/WH	HM	g	Ochre?
3	16751	2A	End scraper	Obsidian	82.2	End scraper edge	SC/WH	Hide	b	
2	17529	2A	End scraper	Obsidian	77.8	End scraper edge	SC/WH	Hide		
	17554	2A	End scraper	Obsidian	52.6	End scraper edge	C/S			
	18843	2A	End scraper	Obsidian	83.7	End scraper edge	SC/WH			
	20552	2A	End scraper	Obsidian	65.4	Lateral edge	C/S			
	20876	2A	End scraper	Obsidian	83.0	End scraper edge	SC/WH			
	21416	2A	End scraper	Obsidian	42.8	Lateral edge	C/S			
	21768	2A	Burin	Obsidian	73.1	Burin facet edge	SC/WH			
1	23923	2A	Microblade	Obsidian		Lateral edge			a	Hafting trace?
7	24122	2A	Burin	Obsidian	68.3	Burin facet edge	SC/WH			
						Burin facet edge	C/S			
					60.3	Platform of burin spall	SC/WH			
	24161	2A	Burin spall	Obsidian	151.7	Burin facet edge	SC/WH			
12	24204	2A	Burin spall	Obsidian	65.6	Burin facet edge	SC/WH	Hide	k	
	S01053	2A	End scraper	Obsidian	93.4	End scraper edge	SC/WH			
	21433	2B	End scraper	Obsidian	59.9	End scraper edge	SC/WH			
9	23457	2B	Burin	Hard-shale	121.7	Burin facet edge	SC/WH	Hide	h	
	23465	2B	Burin spall	Obsidian	85.9	Burin facet edge	SC/WH			
	24349	2B	Burin	Obsidian	55.0	Burin facet edge	SC/WH			

C/S, cutting or sawing; SC/WH, scraping or whittling
ABI, antler, bone, ivory; HM, hard material

Table 5. Working edges of stone tools from the BL2A and BL2B

	End scraper edge	Burin facet edge	Plat form of burin facet	Lateral edge	Total
End scraper	10			5	15
Burin		7	2		9
Burin spall		5			5
Blade				2	2
Total	10	12	2	7	31

Table 6. Use motions of stone tools from the BL2A and BL2B

	C/S	SC/WH	Total
End scraper	6	9	15
Burin	1	8	9
Burin spall		5	5
Blade	2		2
Total	9	22	31

C/S, cutting or sawing; SC/WH, scraping or whittling

Table 7. Worked materials of stone tools from the BL2A and BL2B

	ABI	HM	Hide	Total
End scraper			4	4
Burin		1	3	4
Burin spall	2		1	3
Blade			1	1
Total	2	1	9	12

ABI, antler, bone, ivory; HM, hard material

accompanied with distinctive edge-rounding and perpendicular striations (Figures 4: 3, Photo b). The features of these traces suggest that the scraper edge was used for scraping dry hides. In addition, the lateral edges of end scrapers show two types of polish; a dull, pitted, and matt surface (Figure 4: 5, Photo d), and a bright, smooth, but relatively pitted surface (Figure 4: 4, Photo c), all of which are accompanied with parallel striations. The appearance of the polished surface and striations suggests that lateral edges were utilised for sawing or cutting dry and relatively fresh hides. Depending on the relative

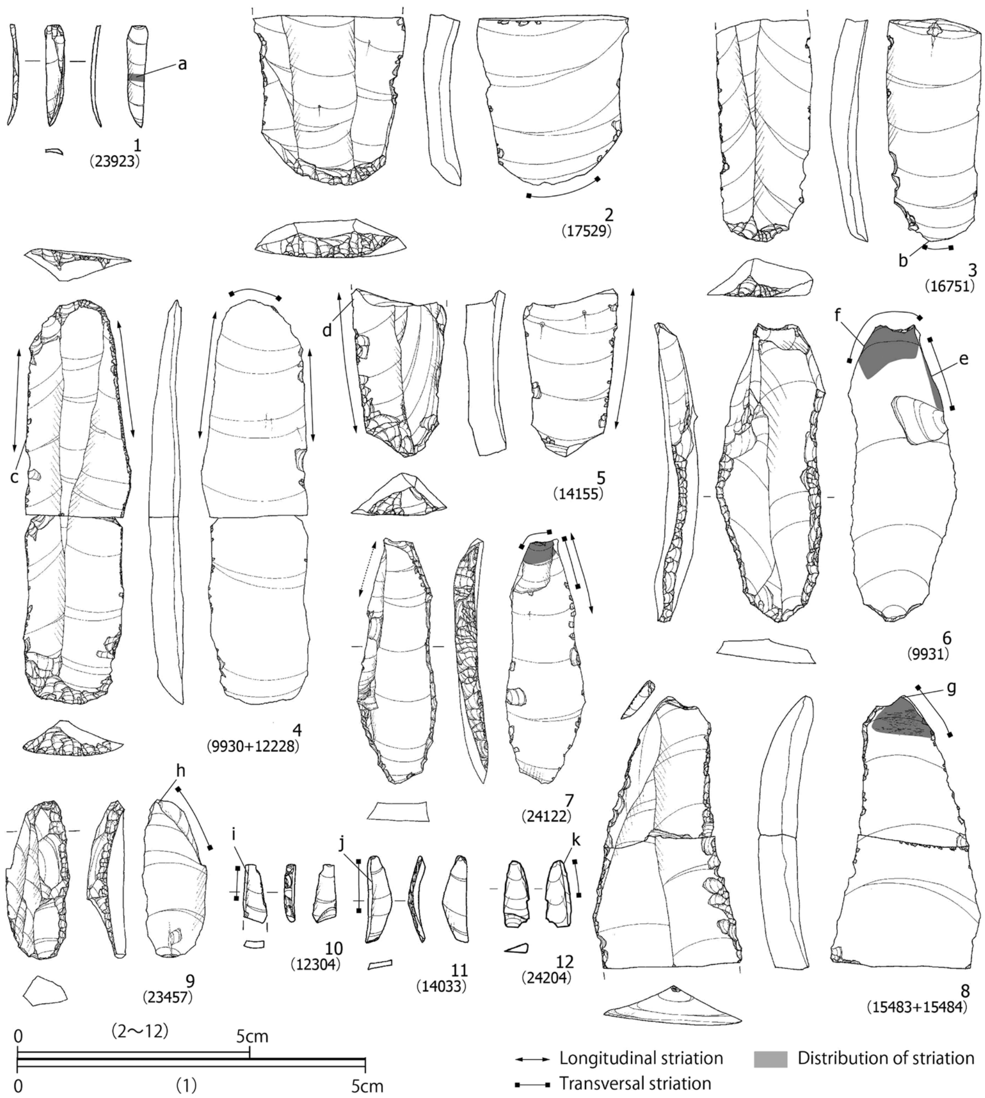

Figure 4. Stone tools bearing the use-wear traces (after Sato and Yamada 2014). 1, microblade; 2–5, end scrapers; 6–9, burins; 10–12, burin spalls

amount of bone, fresh, skin, and hair contacts, experiments involving butchering activities sometimes produce use-wear traces that partially resemble the dry and fresh hide polishes (Iwase 2014). Thus, the microwear on the lateral edges of end scrapers may imply the butchering activity and/or relevant tasks such as skinning, defleshing, and dehairing.

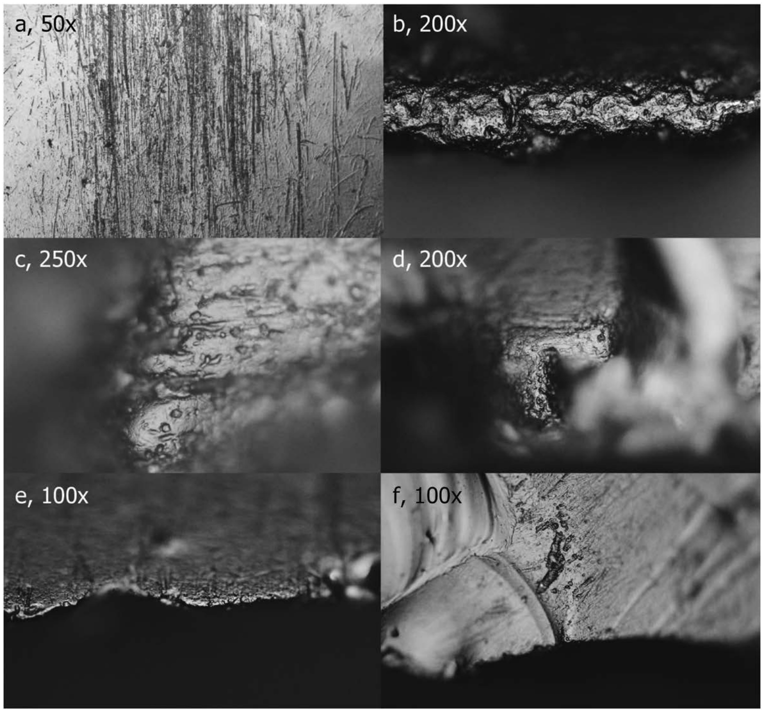

Figure 5. Use-wear traces observed on a microblade, end scrapers, and burins. Photo a shows numerous perpendicular striations. Photo b shows polishes from dry hide working. Photos c, d, e, and f show polishes from processing relatively fresh hides

In addition, striations on the lateral edges were frequently cut off by the retouches on the distal ends of end scrapers (Figure 4: 4, 5). This indicates the possibility that the lateral edges of blades or side scrapers were initially employed for longitudinal activities, and were then modified into end scrapers.

(3) Burins

Out of seven selected burins, six specimens possess definite signs of having been used (Table 3). A total of nine zones provide clear evidence that allows the estimation of working edges and motions of use (Tables 5, 6), as well as four zones that allow determination of worked materials (Table 7). Of these, use-related traces are mainly located on burin facet edges, and striations are perpendicularly or obliquely running to the working edges (Figure 4: 6–9). This means that facet edges were chiefly used for the transverse motions including scraping and whittling (Tables 5, 6). On the other hand, a facet edge that shows parallel striations to the working edge (Figure 4: 7) is suggestive of occasional use of sawing or cutting activities. Furthermore, burin facet edges show three types of use-wear; (1) Polishes exhibiting a matt, pitted, and bumpy appearance spreading over the concave areas (Photos h); (2) Polishes having a relatively bright and smooth-greasy surface (Photo e), and; (3) Distinctive edge abrasion accompanied with a large amount of microchipping (Photo g). These morphological features of microwear suggest that dry hide working led to the first type of traces, while the second was produced by processing fresh hides. The third traces demonstrating the remarkable edge damage imply that this facet edge contacted relatively hard materials. Of particular interest is the fact that red adhesive materials can be observed into the concave areas of microchipping, implying that this edge may have been used for processing with ochre.

In addition to traces on the burin facet edges, two zones of spall platforms also bear use-related traces. The striations are perpendicularly or obliquely running to the working edges (Figure 4: 6, 7), suggesting that they were used for scraping or whittling activities (Tables 5, 6). The ridge of the microscar shows a polished surface with a bright, smooth, but relatively pitted appearance (Photo f). This polish type and striations demonstrate that truncated platforms for spall removal were also used for the transversal motion of fresh hides.

(4) Burin spalls

Out of 43 selected burin spalls, only five samples exhibit clear microscopic traces. A total of five zones provide evidence for the estimation of working edges and motions used (Tables 5, 6), while three zones allow the determination of worked materials (Table 7). In all cases, use-wear traces are exclusively located on previous burin facet edges on dorsal surfaces (Table 5). This means that burin spalls were detached from burins in order to rejuvenate the worn facet edges. Similar to burins, perpendicular or oblique striations are running on the working edges (Figure 4: 10–12), suggesting the scraping or whittling activity (Table 6). Burin spalls yield clear evidence of antler, bone, ivory (ABI), and hide processing; a bright, smooth, and flat appearance with a sharp contrast to the unaltered surface that expands mainly on microtopographically higher points of the edge (Photos i, j), as well as a bright, smooth, but relatively pitted surface (Photo k).

Of particular interest is that the hide polishes were from facet edges of both obsidian and hard-shale burins and burin spalls (Figure 4: 6, 9, 12); on the contrary, definite ABI polishes were exclusively observed on the hard-shale samples (Figure 4: 10, 11; Table 4). This implies that obsidian burins may have been used primarily for hide working; while on the other hand, hard-shale burins seem to have served a function mainly for scraping or whittling ABI materials. The transverse motions such as scraping, whittling, shaving, and planing generally undertook the artisanal and craft activities to shape worked materials into the specific forms (e.g., Yamada 2008; Iwase 2011, 2012). Thus, traces from scraping or whittling the ABI materials mean that hard-shale burins seem to have

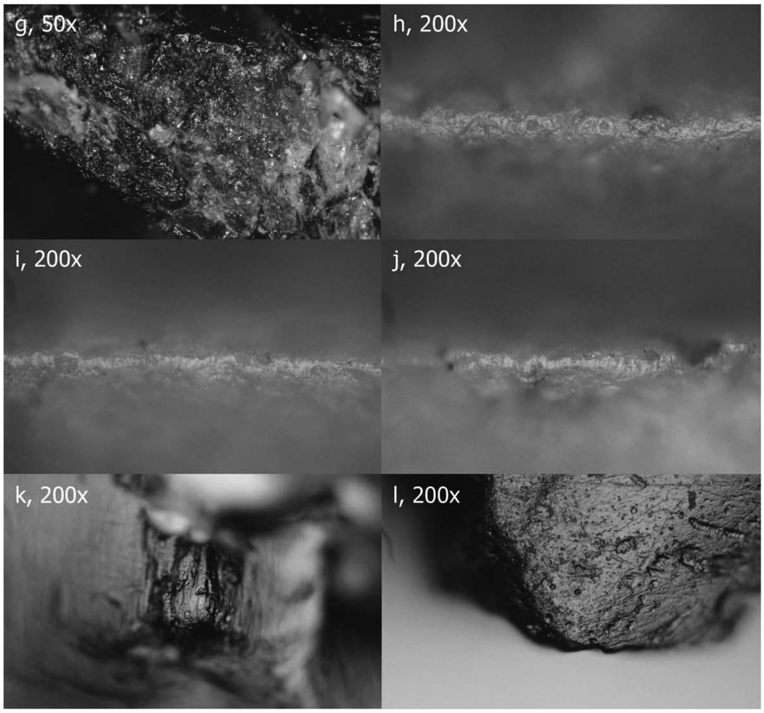

Figure 6. Use-wear traces observed on burins, burin spalls, and a blade. Photo g shows the distinctive edge abrasion with a large number of microchipping. Photos h and k show polishes from hide working. Photos i and j show polishes from processing antler, bone, or ivory accompanied with perpendicular striations. Photo l shows polishes from processing relatively fresh hides

been used for shaping osseous implements such as the microblade-slotted shafts.

(5) Blades

From 25 samples, two blades show definite use-wear. Of these, two zones provide evidences to estimate which edges were working and how they were used (Tables 5, 6), and a zone indicates what materials were processed (Table 7). The microwear can be observed on lateral edges, which bear striations running parallel to the working edges (Tables 5, 6), indicating that blades were served as sawing or cutting tools with their lateral edges. A used zone illuminates distinctive edge rounding accompanied with a dull, pitted, and matt polish (Photo l). The features of traces suggest that the lateral edge was employed for processing hides (Table 7). Similar to the lateral edges of end scrapers, blades may also have been employed for skinning, defleshing, and/or dehairing activities.

(6) Other tools

Macro- and microscopic analyses reveal that other tools, including a platform spall of microblade core, a stemmed point, bifaces, side scrapers, drills, flakes and an edge-ground axe, bear no distinctive use-wear traces. These results also suggest that these implements may have been used for short durations and discarded before the formation of clear traces, or that they may have been rarely utilized. A tuff axe, however, shows the remarkable weathering on all its ridges, and thus we cannot deny that use-related traces may have disappeared during the depositional and post-depositional processes.

5. Discussions and conclusion

Based on the IUZs of reliable use-wear traces from the BL2A and BL2B concentrations, Table 8 summarises the relationships between tool types, working edges, use motions, and worked materials. Results show that an end scraper was employed for hide scraping with its scraper edge on distal end (33.3%, 1/3 IUZ), and lateral edges were for longitudinal motions of hides (66.7%, 2/3 IUZs). Facet edges of burins and burin spalls seem to have been used for scraping or whittling hides (42.9%, 3/7 IUZs) and hard materials including ABI (42.9%, 3/7 IUZs). Platforms of burin spall removals were occasionally also employed for hide processing (14.3%, 1/7 IUZ). One blade (100.0%, 1/1 IUZ) shows traces resulting from cutting or sawing hides on its lateral edge.

Similar patterns in functional relationships were observed on toolkits from the BL1 and BL3 concentrations (Iwase 2014; Iwase *et al.* 2016) (Tables 9, 10). Indeed, these

Table 8. Functional correlations of stone tools from the BL2A and BL2B, based on the IUZs

	End scraper edge	Burin facet edge			Platform of burin spall	Lateral edge
	SC/WH	SC/WH			SC/WH	C/S
	Hide	ABI	HM	Hide	Hide	Hide
End scraper	1					3
Burin (total)			1	2	1	
(obsidian)			1	1	1	
(hard-shale)				1		
Burin spall (total)		2		1		
(obsidian)				1		
(hard-shale)		2				
Blade						1

C/S, cutting or sawing; SC/WH, scraping or whittling
ABI, antler, bone, ivory; HM, hard material

Table 9. Functional correlations of stone tools from the BL1, based on the IUZs

	End scraper edge	Burin facet edge		Lateral edge		
	SC/WH	SC/WH		C/S	C/S	SC/WH
	Hide	ABI	Hide	Hide	MM	Hide
End scraper	2			4		
Burin (total)		1	2			
(obsidian)			1			
(hard-shale)		1	1			
Burin spall (total)		1				
(hard-shale)		1				
Side scraper						1
Blade				1	1	

C/S, cutting or sawing; SC/WH, scraping or whittling
ABI, antler, bone, ivory; MM, medium hard material

Table 10. Functional correlations of stone tools from the BL3, based on the IUZs

	Tip	End scraper edge	Burin facet edge		Drill bit	Lateral edge		
	PR	SC/WH	SC/WH		CAR	C/S		
		Hide	ABI	Hide	ABI	ABI	Hide	MM
Microblade	1							
End scraper		4					3	1
Burin (total)				2		1		
(obsidian)				1		1		
(hard-shale)				1				
Burin spall (total)			21	2				
(obsidian)				1				
(hard-shale)			21	1				
Burin-end scraper							1	
Drill					1			
Blade							1	
Biface	1							

PR, projectile; C/S, cutting or sawing; SC/WH, scraping or whittling; CAR, carving
ABI, antler, bone, ivory; MM, medium hard material

tables illuminate that end scrapers served as hide processing tools with their distal and lateral edges. The facet edges of burins seem to have performed two functions; primarily to shape ABI materials and secondly to process hides. In addition, clear ABI polishes were exclusively observed on hard-shale burins and burin spalls. The edge angles of burin facets show significant differences between obsidian and hard-shale specimens (Iwase *et al.* 2016). In sum, obsidian burins with relatively sharp facet edges may have been primarily used for hide working; on the contrary, hard-shale burins with acute edges show a strong correlation with ABI materials. It is clear that blades from the BL1 and BL3 were also employed for sawing or cutting hides. Although based on small samples, it is even more interesting that other tasks or functions, such as hunting activities and carving ABI materials, were performed by other tools, including microblades, bifaces, and drills (Table 10). In addition, Kanomata (2015) analysed use-wear traces on hard-shale burins and burin spalls which were recovered from another Oshorokko-type microblade assemblage at the Inada 1 site. His analyses also revealed that facet edges were employed chiefly for scraping or whittling ABI materials followed by hide working. Thus overall, these results indicate that association between tool type and function may not have been at random; rather, each late Microblade tool roughly correlated with a small number of specific functions (Tables 8, 9, 10).

As Torrence (1983: 13) has suggested, high residential mobility should place constraints upon a forager's technology by imposing carrying cost for tools. In addition, the constraint requires a small set of more generalised multifunctional tools that restrict the degree to which specialisation of tools can take place (e.g. Bousman 1993; Odell 1994; Shott 1986; Torrence 1983, 1989). Yamada (2006), for example, has proposed that the inter- and intra-site variability of stone toolkits seems to have became more remarkable in the late Microblade assemblages, based on the results of factor analyses on almost all Microblade sites in Hokkaido. Thus following Yamada's (2006) suggestion, the occurrence of task-specific occupation and increases in logistical mobility can be also postulated for the late Microblade. To respond technologically to this change, specialised tools designed to perform a limited range of functions would have been required.

During the LG period, environments on the southern Palaeo-SHK Peninsula seem to have been characterised by a remarkable fluctuation between coniferous forests and open-forest taiga with grasslands where large-sized mammals of Mammoth Fauna may have gradually disappeared and medium to small-sized animals, including *Cervus*, started to flourish (Yamada 2006). To adjust the technological organization to such a dramatic change in climate, flora, and fauna, UP foragers in the LG Hokkaido seem to have introduced mobility strategies that are characterized by relatively frequent logistical forays, as shown by the remarkable variability in stone toolkits seen between four lithic concentrations in Yoshiizawa (Table 2). In addition, the results of this study imply that foragers honed their lithic technologies towards the production of a diversified set of relatively specialised tools (Tables 8, 9, 10). Although the present paper reveals no distinctive use-wear traces from bifacial-stemmed points and edge-ground axes, elucidating the functions of these newly invented tools will also provide important clues to understand technological adaptations to the LG environments on the southern Palaeo-SHK Peninsula.

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