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ARTICLE

Early Beringian Traditions: Functioning and Economy of the Stone Toolkit from Swan Point CZ4b, Alaska

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Abstract

The pressure knapping technique develops circa 25,000 cal BP in Northeast Asia and excels at producing highly standardized microblades. Microblade pressure knapping spreads throughout most of Northeast Asia up to the Russian Arctic, and Alaska, in areas where the human presence was unknown. Swan Point CZ4b is the earliest uncontested evidence of human occupation of Alaska, at around 14,000 cal BP. It yields a pressure microblade component produced with the Yubetsu method, which is widespread in Northeast Asia during the Late Glacial period. Through the techno-functional analysis of 634 lithic pieces from this site, this study seeks to identify the techno-economical purposes for which the Yubetsu method was implemented. Data show that the microblade production system is related to an economy based on the planning of future needs, which is visible through blanks standardization, their overproduction, their functional versatility, and the segmentation of part of the *chaîne opératoire*. This expresses the efficiency and economic value of the microblade production system. The flexible use of pressure microblades identified at Swan Point CZ4b is also found in Japan, Korea, Kamchatka, and the North Baikal region, suggesting that their modes of use accompany the spread of early microblade pressure knapping over an immense territory across Beringia.

Les débitages par pression émergent ca. 25,000 cal BP au Nord-Est de l'Asie et permettent la confection de lamelles particulièrement standardisées, notamment au moyen de la méthode Yubetsu (i.e., débitage lamellaire à partir de préformes bifaciales). Ce bagage technique novateur accompagne le développement de l'occupation humaine en zone arctique et subarctique pendant le Dernier Maximum Glaciaire et le Tardiglaciaire et se retrouve dans la plupart de l'Asie du Nord-Est jusqu'à l'Arctique russe, et en Alaska. Swan Point CZ4b livre les plus anciennes industries connues en Alaska (ca. 14,000 cal BP) et c'est également le seul site d'Amérique du Nord où le débitage lamellaire est exclusivement réalisé selon la méthode Yubetsu. À partir de l'analyse techno-fonctionnelle d'un corpus de 634 pièces lithiques de ce site, l'objectif est d'identifier les finalités techniques pour lesquelles était mise en œuvre la méthode Yubetsu, en questionnant le fonctionnement et l'économie de l'outillage. Les données acquises révèlent que le débitage lamellaire par pression était lié à une forte anticipation des besoins (i.e., standardisation des lamelles permettant de répondre aux contraintes de l'emmanchement ; surproduction en prévision des besoins futurs en outils non usés ; possible transport de préformes bifaciales permettant de différer leur utilisation ; production de préformes bifaciales utilisées comme outil et comme nucléus) et ne répond pas à une spécialisation fonctionnelle : les lamelles ont servi en armature de couteau pour la découpe voire le raclage, et en armature de projectile. Cette flexibilité fonctionnelle des lamelles par pression est également présente au Japon, en Corée, au Kamtchatka et en Sibérie orientale, ce qui suggère que leurs modalités de mise en œuvre ont accompagné la diffusion des premières technologies lamellaires par pression sur un territoire immense, de part et d'autre du détroit de Béring.

Keywords: Late Glacial; Alaska; adaptative strategies; Beringia; stone tools; use-wear analysis; lithic technology

Mots clés: Tardiglaciaire; Alaska; stratégies adaptatives; Béringie; industrie lithique; analyse fonctionnelle; technologie lithique

The earliest known evidence of human occupation of the Arctic is dated to 30,000 to 47,000 cal BP and is mostly located in the Yana Valley in the Russian Far North (Yana RHS, 71°N; Pitul'ko et al. 2016, 2017). Few archaeological sites prior to the Last Glacial Maximum (26,500–19,500 cal BP; Clark et al. 2009) are known in arctic and subarctic zones, and proof of human presence intensifies in these areas during the Late Glacial period (Goebel 2002; Pitul'ko et al. 2017). In Beringia, they coincide with the adoption and spread of an innovative toolkit characterized by the production of microblades obtained by pressure knapping, using the Yubetsu method or a variant (e.g., Oshorokko, Shirataki, Sakkotsu, Saikai; Flenniken 1987; Gómez Coutouly 2011; Inizan et al. 1992; Nakazawa et al. 2005; Yoshizaki 1961). This method consists of shaping a bifacial preform, opening the striking platform longitudinally, removing a crested blade, and then removing microblades at one end of the bifacial preform (Supplemental Figure 1). The use of the pressure knapping allows unprecedented standardization of microblades and a high productivity for each core (Gómez Coutouly 2011; Inizan et al. 1992). The Yubetsu method and its variants seemingly emerged circa 25,000 cal BP in Far East Asia (Gómez Coutouly 2018), the Siberian-Chinese-Mongolian area (Inizan 2012; Inizan et al. 1992) or southern Siberia (Kuzmin et al. 2005), spread through most of the Russian Far East to the Russian Arctic, such as at Berelekh in Yakutia (71°N; Mochanov and Fedoseeva 1996) or at Ayon in Chukotka (69° N; Gómez Coutouly 2011; Slobodin 2001), and was carried along with the early known peopling of Alaska at Swan Point CZ4b (64°N; Holmes 2001; Figure 1) at a time when the Beringian Land Bridge between the Asian and American continents was present (Duvall et al. 1999).

The Yubetsu method persisted for over 10,000 years across an immense territory involving various ecosystems and landscapes throughout subarctic and arctic regions. This method of microblade production plays a structuring role in the understanding of the technological dynamics of Northeast Asia and northwestern North America at the end of the Pleistocene. Through the techno-functional analysis of stone tools from Swan Point CZ4b, we seek to understand how this highly innovative technology was implemented, was organized, and contributed to the peopling of northern latitudes by Late Pleistocene hunter-gatherer societies.

The techno-functional analysis is implemented to define the function of tools in relation with their morphology and production system, combining use-wear data and technological data. It enables the characterization of the activities performed with the tools and the understanding of the biography of tools, and it gives key elements to define the site function. It provides access to the organization of activities related to the acquisition and transformation of resources available in the environment and, consequently, to the subsistence strategies and ways of life of human groups. This approach is fundamental to link the techniques used by past nomadic hunter-gatherers and the environments they lived in. This study presents pioneer techno-functional data for a Late Pleistocene microblade component in Alaska and therefore gives key elements to explain what technical and economical solutions the microblade system offered in cold regions during the early stages of colonization of North America by way of Alaska.

Swan Point and the Peopling of Eastern Beringia

Because Alaska is an inevitable step for entering the American continent from western Beringia by land, the regional archaeology is essential in reflecting on the initial peopling of the Americas. The Pleistocene sites of Alaska are mostly located in the Tanana and Nenana Valleys in central Alaska (Bever 2006; Blong 2018; Holmes 2001; Potter et al. 2013; Figure 2). The site of Swan Point in the Tanana Valley yields the earliest known occupation of Alaska, being dated to circa 14,000 cal BP by 15 consistent AMS radiocarbon dates (Hirasawa and Holmes 2017; Holmes 2011; Lanoë and Holmes 2016; Potter et al. 2013; Reuther et al. 2023; Supplemental Table 1). It is currently the only known site in northern North America where the Yubetsu method is exclusively used to systematically produce microblades (Gómez Coutouly and Holmes 2018). Swan Point is therefore a major site for Alaskan archaeology—because of its ancient chronology and its specific technology—that can be

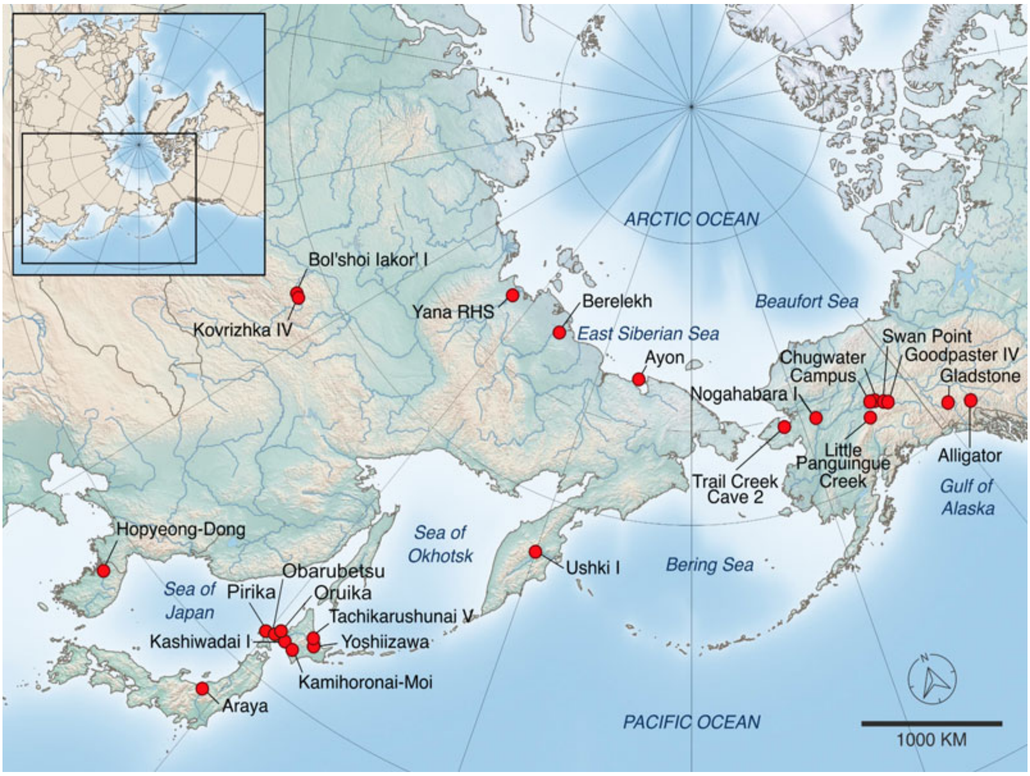

Figure 1. Location of the sites mentioned in the text. Basemap: raster data, Natural Earth; vector data, Natural Earth, Alaska Department of Natural Resources Open Data. (Illustration by Constance Thirouard, used with permission.)

related to the Northeast Asia Dyuktai complex (Holmes 2001; Mochanov 1980; Vasil'ev et al. 2002; Yi et al. 1985). Consequently, it offers some of the oldest evidence of the cultural connection between America and Asia.

Swan Point, discovered in 1991, is a stratified open-air site composed of several Late Pleistocene and Holocene layers; the most ancient is CZ4b (Holmes 2001, 2011). This cultural zone exhibits good spatial preservation of the archaeological material thanks to a relatively unaltered loessic deposit (Dilley 1998; Kielhofer et al. 2020) and allows for detailed palethnologic interpretations. Lithic artifacts and faunal remains are concentrated around two hearths. The faunal assemblage comprises 1,257 remains (Lanoë and Holmes 2016), composed of mammoth (*Mammuthus primigenius*), horse (*Equus lambei*), caribou (*Rangifer tarandus*), and birds—including waterfowl: goose (*Anser*) and swan (*Cygnus columbianus*)—that lived in a tundra environment (Bigelow and Edwards 2001; Lanoë and Holmes 2016).

An Integrated Lithic Approach

This study is based on techno-functional analysis, which is particularly adapted to approach socio-environmental questions because it allows linking mineral, animal, and vegetal resources, which are available in the environment, with past technical traditions. Our study brings pioneer data because use-wear analysis has rarely been implemented in Alaska. So far, it has only appeared as part of master's theses (Flanigan 2002; Hall 2015) and in two articles focused on the stone tools from the Nenana Valley: (1) a mid-Holocene strike-a-light from Goodpaster IV was analyzed by Colas Guéret (Gómez Coutouly et al. 2015), and (2) the functioning of the Early Holocene cobble tools from Little Panguingue Creek was analyzed by Caroline Hamon (Gómez Coutouly et al. 2023).

The traceology sample of Swan Point CZ4b includes 634 pieces that represent the diversity of raw materials and categories of lithic products. Use-wear data were combined with taphonomical

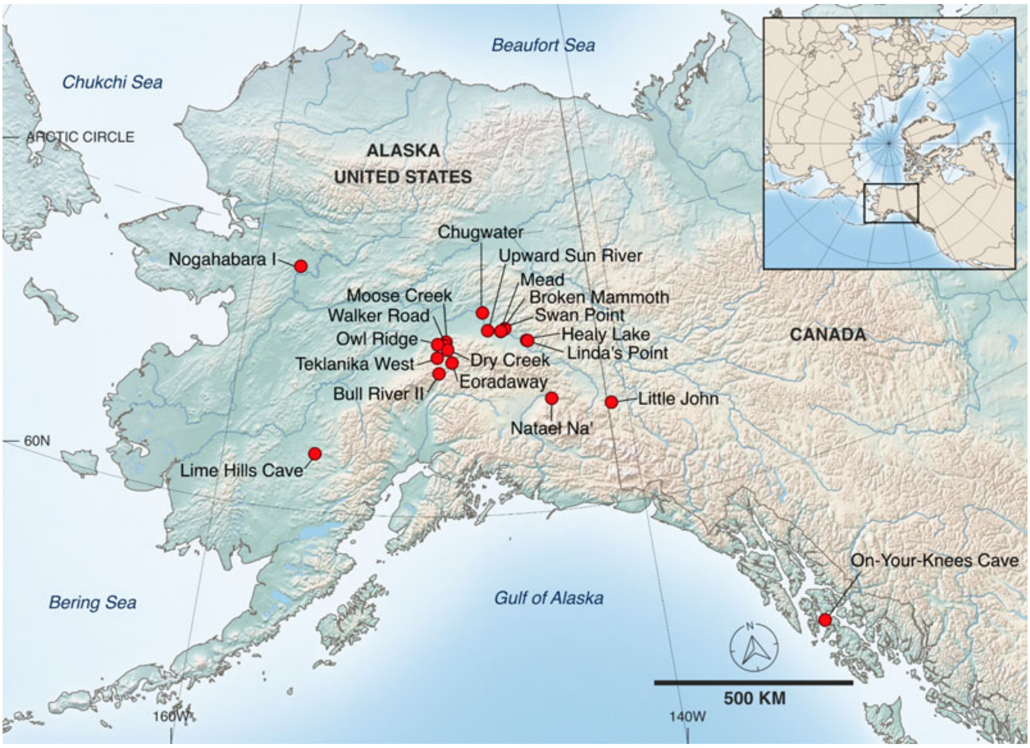

Figure 2. Location of the main Late Pleistocene sites of Alaska. Basemap: raster data, Natural Earth; vector data, Natural Earth, Alaska Department of Natural Resources Open Data. (Illustration by Constance Thirouard, used with permission.)

(Supplemental Figures 2 and 3), technological (Gómez Coutouly and Holmes 2018), and petroarchaeological data (Hirasawa and Holmes 2017) to define *chaînes opératoires* from rock procurement to knapping, use, management, and discard of tools, followed by postdepositional processes. This integrated approach enables us to (1) engage a systemic reflection on the techno-economic solutions adopted by Pleistocene societies to settle in Alaskan subarctic environments and (2) determine if these solutions were shared with Northeast Asia.

The taphonomic analysis is a prerequisite to any functional interpretation because it makes it possible to distinguish natural traces from anthropic ones and establish the postdepositional processes undergone by artifacts. Thirty percent of the sample was analyzed using an analytical table describing alterations on rock surfaces through intensity and organization of postdepositional shine, rounding, dissolution, scars, crushing, bright spots, encrusting, and striations, as well as thermal alteration markers. The definition of the intensity of alteration traces is based on an ongoing collective work initiated by Paul Fernandes, Lorène Chesnaux, and Vincent Delvigne (Delvigne et al. 2020; Gauvrit Roux and Fernandes 2022). The identification of alteration damages on knapped stone tools is based on experiments that, notably, analyze the effects of trampling or sediment compaction (Chesnaux 2014; Claud 2008; Gauvrit Roux 2019; Prost 1988; Tringham et al. 1974), of ice or frozen ground (Caspar et al. 2003), of mechanical friction (Levi Sala 1986), of thermal alteration (Clemente Conte 1997), of white patina (Rottländer 1975), or of chemical attacks on the preservation of use polish (Plisson 1985).

The taphonomic, technologic, and functional wear were examined by combining macro- and microscopic observation of rock surfaces using binoculars (Wild 6×–31×), a digital microscope (Dino-Lite 10×–150×), and an optic metallurgical microscope (Nikon Eclipse LV150 50×–500×). After an initial macroscopic observation, pieces without residues were cleaned under tepid running water with soap, applying only low pressure on the rock with a toothbrush; alcohol was then locally applied using delicate-task dry wipes. This cleaning protocol enables removing sediment and handling grease from the rock surface before the microscope observation.

Functional interpretations of the total sample are based on the combined analysis of micro- and macrowear: scars, fractures, rounding, shine, striations, polish, and residues (Claud 2008; Gauvrit Roux 2019; Hayden 1979; Ibáñez Estévez and González Urquijo 1994; Keeley 1980; Semenov 1957; Vaughan 1981). Each type of wear is described according to its attributes (e.g., location, organization, morphology, orientation, intensity, delineation), which are combined to reach a functional interpretation based on actualistic experimental reference frames and the ethnoarchaeological record.

The identification of projectile inserts is based on diagnostic impact traces (Chesnaux 2014; Coppe and Rots 2017; Fischer et al. 1984; Gauvrit Roux et al. 2020; Rots and Plisson 2014), which include bending, burin-like, and spin-off fractures whose length is greater than or equal to 2 mm (Supplemental Figure 4); low-angle impact scars with a bending initiation whose length is greater than or equal to 1 mm; and linear impact traces associated with an impact fracture or scar.

Impact scars form under conditions other than cutting, scraping, or perforating scars, and they can be distinguished from one another based on the analysis of traces combination: during a cutting, scraping, or perforating task, there is prolongated friction between the worked material and the tool, so scars of the working edge are associated with a series of other types of wear, including polish, striations, or rounding. Lithic inserts suffer a violent shock upon impact, so the contact between the target and the projectile is short and the friction is limited in time, which is why scars are not associated with the same combination of polish, striations, and rounding specific to prolonged pressure and friction against a contact material. Experimental projectile inserts may therefore exhibit macroscopic fractures, scars, and, more rarely, striations.

Fractures similar in morphology and length may occur both during knapping and at impact, and it is only when establishing the chronology between fracture and retouch that their origin may be defined. Therefore, when the artifact is not retouched, as is the case with most microblades from Swan Point, projectile inserts are identified when (1) at least two types of impact damage are present on a piece (in this study, an artifact is considered potentially impacted when it displays one single damage type) and (2) impact damages are recurrent in the archaeological assemblage considered.

Tools, Techniques, and People

Tool Production

Swan Point CZ4b yielded over 11,500 lithic artifacts, including thousands of chips, about 900 microblades, 10 microcores, and three bifacial microcore preforms. Formal tools include 33 burins on flakes and one end scraper on a flake (Gómez Coutouly and Holmes 2018). The retouched flakes are quite limited because the assemblage is primarily oriented toward the production of microblades at Swan Point CZ4b.

The vast majority of the microblade and burin technology at CZ4b is made on one specific type of raw material, described by Hirasawa and Holmes (2017) as a grayish-green igneous rock (GGI). The precise nature and source of this raw material is still undetermined. GGI amounts to more than 70% of the production, and secondary rock types include siliceous rocks (chert, chalcedony), rhyolite, basalt, and obsidian (Hirasawa and Holmes 2017). Most diagnostic artifacts are made from GGI, including one microblade core preform, nine of the 10 microblade cores, several hundred microblades, and 10 burins. GGI is very specific to CZ4b, given that in later components of the site—where chert, chalcedony, basalt, rhyolite, and obsidian are common raw materials—GGI is not present (Hirasawa and Holmes 2017). One microblade core is made of a white rhyolite, and one microblade core preform is made of a black chert. The study of the microblade cores and microblades indicates that pressure flaking was the technique employed for the removal of microblades (Gómez Coutouly and Holmes 2018).

As previously described (Gómez Coutouly 2011, 2012; Gómez Coutouly and Holmes 2018; Holmes 2001), microblade production at CZ4b was made according to the Yubetsu method. So far, 12 tablets and one crested blade have been refitted to seven different microblade cores, and others (especially ridge spalls) are yet to be refitted to microblade cores. These refits demonstrate that core preforms were sometimes more than twice as long as the abandoned core. The numerous refits provide the opportunity to reconstruct in detail the different stages of microblade core preform manufacture within a coherent assemblage. The theoretical reconstructions of the complete manufacturing sequence for each individual core not only provides a detailed analysis but also shows consistency in core production (overall size, tablet removal, direction of flake blank, etc.).

Thirty-three burins have been recovered from CZ4b, most being dihedral and transverse burins on truncation on flake. About 34% of burins had refitted spalls (Lanoë and Holmes 2016), and some of them had multiple rejuvenation/sharpening spalls refitted to a single burin. In one instance, at least five consecutive burin spalls were refitted together, although the actual burin is missing, and in another example, up to four spalls were refitted to a single burin. Clearly, more than five spalls could be produced on one single burin, based on the negatives from missing spalls (Gómez Coutouly and Holmes 2018).

Postdepositional Alterations

Postdepositional surface alterations of knapped lithics from Swan Point CZ4b are rare and of low intensity (Supplemental Figure 2): no frost weathering, heating features, or patina are identified. Ancient mechanical damage—such as scars, crushing, rounding, and shine—is absent or light; therefore, surfaces are generally well preserved. These observations coincide with the pedogenesis of the Late Glacial layers of Swan Point that show low influence of cryoturbation and bioturbation features within the sedimentary matrix (Kielhofer et al. 2020). Microwear (polish, striations), however, is generally absent or degraded regardless of the rock type. This may be due to the pH of the loess sediment, given that previous experimentations revealed that use polish on flint may be degraded if exposed to acid or alkaline solutions (Plisson 1985). Further data are needed to refine the understanding of the processes of alteration of the grayish-green igneous rock, basalt, and rhyolite, which may differ from siliceous rocks because their composition and structure are different. When microwear is absent or degraded, it is not possible to define the worked material precisely, but it remains possible to define classes of hardness and abrasiveness of worked materials, the location of the used area (UA), and the applied motion, based on macrowear (fractures, scars, rounding, shine).

A Multipurpose Microblade Component

Microblades are abundant at Swan Point, and of the 414 microblades submitted to use-wear analysis (46% of the CZ4b microblade assemblage of CZ4b), 57 show use wear (14%; Table 1; Supplemental Table 2). Most microblades are broken, and fractures generally have a snap section (85%) with no impact points visible. This type of fracture could have multiple causes, such as alteration, use, knapping, or intentional breakage. The near-systematic breakage of microblades (97%) suggests intentional blanks fracturing. This is supported by the strict selection of fragments; most used microblades are mesial fragments (75%) and, less often, proximal ones (23%), whereas only one unbroken microblade and no distal fragments have use wear (Table 2). This selection indicates a marked preference for highly standardized rectangular tools with a trapezoidal section (93%) and sharp parallel lateral edges (Supplemental Figure 5). In this context, distal fragments, which are thinner than the rest of the blanks (therefore more fragile) and generally have convergent lateral edges, may correspond to by-products of the microblade production process.

Alaskan microblade technology has not been the object of a macro- and microscopic analysis use-wear analysis before, and the widespread hypothesis is that microblades were mainly used as projectile inserts. The use-wear analysis of a large microblade corpus from CZ4b shows that these tools were actually used to perform a variety of tasks: six microblades (11%) have long spin-off fractures and invasive lateral edge scarring (Figure 3), indicating that part of the microblades were indeed used as projectile inserts. Most microblades with use wear (89%), however, were not used as projectile inserts but were employed as knife inserts to cut and scrape varied materials (dry hide, butchery, soft and semi-hard materials; Supplemental Table 2). Traces are more often located on the left edge (79%) than on the right one; all used edges are acute (37° on average), and they are mostly unretouched, except in two cases where a marginal inverse retouched back is shaped on the used edge. Scraping and cutting/sawing traces overlap on the lateral edge of six tools, reinforcing this idea of functional flexibility of microblades, which appear to have been multipurpose tools.

In parallel, the use of by-products of the microblade production is rare (Table 1). However, as observed in the rare use-wear reports in western Beringia, such as Ushki I in Kamchatka (Dikov

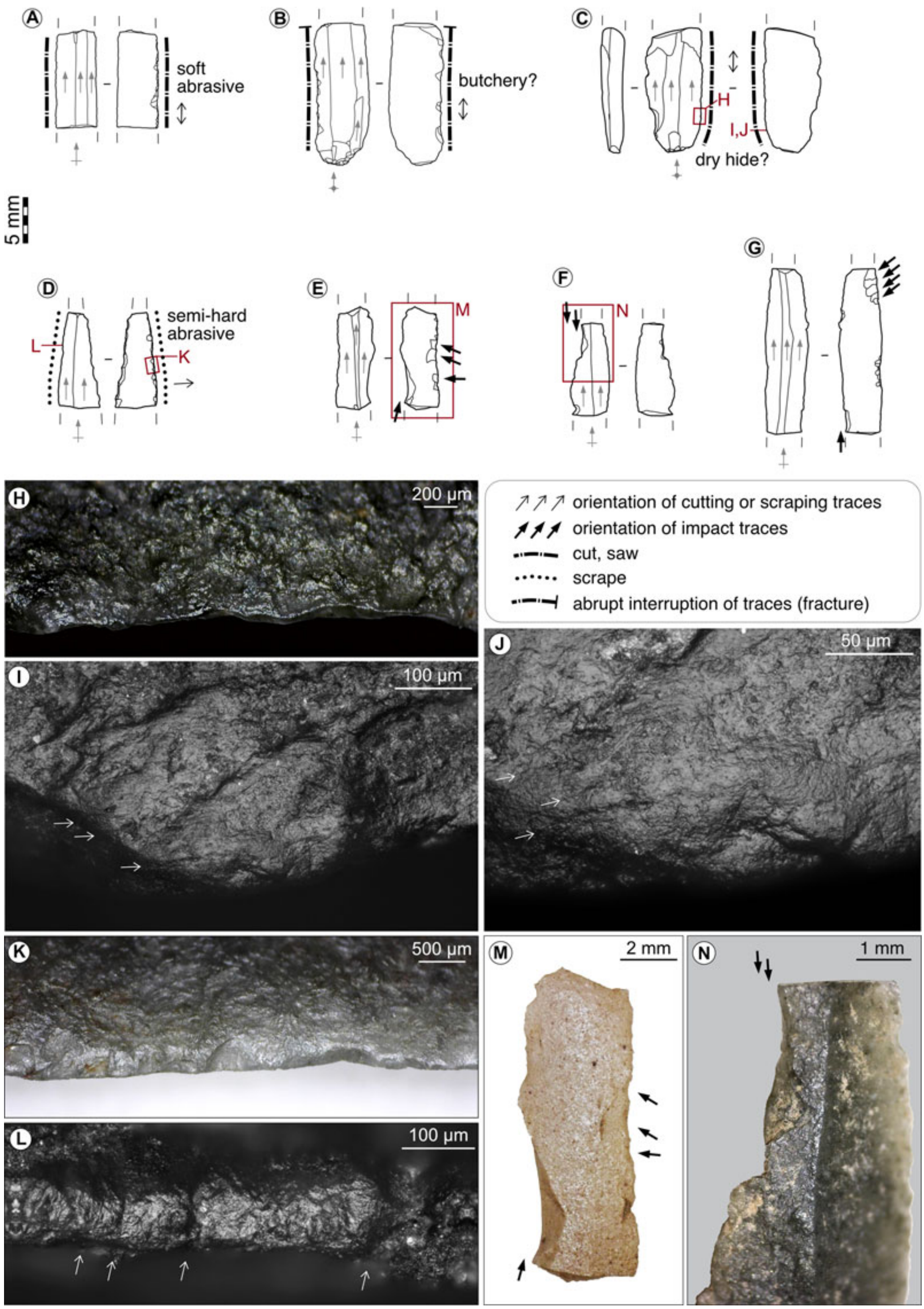

Figure 3. Used microblades: (A) mesial fragment used to cut soft abrasive material; (B) proximal fragment probably used for butchery; (C) proximal fragment used for dry hide cutting; (D) mesial fragment used to scrape semihard abrasive material; (E, F, G) mesial fragments used as projectile inserts; (H) moderate rounding and shine; (I, J) rounding, thin striations parallel to the edge, and altered irregular and dull polish related to dry hide cutting; (K) scars perpendicular to the edge; (L) rounding and thick striations parallel to the edge related to scraping a semihard abrasive material; microwear is altered; (M, N) spin-off fractures due to the impact. (CAD by Eugénie Gauvrit Roux.) (Color online)

Table 1. General Results of the Use-Wear Analysis.

Type		Analyzed Sample	Excluded	Undet.	Motion Undet.	Cut/ Saw	Incise	Scrape	Cut/ Saw + Scrape	Cut/Saw + Scrape?	Dig?	Percussion	Impacted	Impacted?	Total with Use Wear	Transport Traces	
																Yes	Probable
Tools on flake	Burin	12	—	—	—	—	—	5	—	—	—	—	—	—	5	3	3
	Burin scraper	1	—	—	—	—	—	1	—	—	—	—	—	—	1	—	—
	End scraper	1	—	—	—	—	—	1	—	—	—	—	—	—	1	1	—
	Tool fragment	1	—	—	—	—	—	1	—	—	—	—	—	—	1	—	—
	Burin spall	46	—	—	—	1	—	8	—	—	—	—	—	—	9	3	2
Microblade production	Microblade (unretouched)	414	1	2	3	30	—	10	1	5	—	—	2	4	55	—	—
	Backed microblade	2	—	—	—	1	—	1	—	—	—	—	—	—	2	—	—
	Microcore or burin	13	—	—	—	—	—	—	—	—	—	—	—	—	—	3	1
	Microcore	10	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—
	Crested blade	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Under-crested blade	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Crested microblade	7	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
	Under-crested microblade	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Plunging microblade	2	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
	Microblade-like flake	10	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—
	Blade-like flake	3	—	—	1	—	—	—	—	—	—	—	—	—	1	—	—
	Technical elongated flake	2	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
	Bifacial preform	3	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Bifacial preform fragment	7	—	—	—	1	—	1	—	—	1	1	—	—	4	2	—
	Bifacial shaping flake	6	—	—	—	1	—	—	—	—	—	—	—	—	1	3	1
	Ski spall	49	—	1	—	—	—	—	—	—	—	—	—	—	—	2	—
Flake (unretouched)		18	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—
Fragment		10	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—
Chip		12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total		634	5	3	4	34	1	29	1	5	1	1	2	4	81	25	7
%		100	0.8	0.5	0.6	5.4	0.2	4.6	0.2	0.6	0.2	0.2	0.3	0.6	12.8	3.9	1.1

Notes: Undet. = Undetermined. Numerals indicate number of tools.

Table 2. Actions Performed with the Microblades According to Their Fragmentation.

Action Performed	Whole	Proximal	Mesial	Distal	Total
Cut/saw	1	8	22	—	31
Scrape	—	2	9	—	11
Cut/saw + scrape	—	—	1	—	1
Cut/saw + scrape?	—	1	4	—	5
Impacted	—	—	2	—	2
Impacted?	—	1	3	—	4
Motion undetermined	—	1	2	—	3
Undetermined if used	—	1	1	—	2
Excluded	—	—	1	—	1
No use wear	18	121	164	51	354
Total	19	135	209	51	414

Note: Numerals indicate number of tools.

and Kononenko 1990) and at Kovrizhka IV in Oriental Siberia (Gauvrit Roux et al. 2021), several bifacially prepared microcore preforms and fragments of preforms from Swan Point show traces of use prior to the opening of the striking platform (Figure 4). Four pieces were used to cut relatively soft materials with a long edge, and one bifacial tip was used on soft mineral. Bifaces were therefore both tools and core preforms with long biographies (including shaping, use and reuse, reshaping, and microblades knapping). They were used for varied tasks, and neither in the abovementioned Siberian sites nor at Swan Point were those tasks so destructive that they would prevent further knapping of the core by damaging the edges and generating incipient fractures. This is because each bifacial preform is a reserve of several tens or hundreds of microblades (Dikov and Kononenko 1990; Gómez Coutouly 2011).

Technical Valorization of Tools Shaped on Flake

Retouched flakes are infrequent in the CZ4b assemblage (0.3% of the lithic assemblage and 2% of the analyzed sample), but they were valued items in the toolkit. Even in a context where microwear is not well preserved, they often show use wear (i.e., half of them show traces of use, which is more than for any other lithic category; Table 1), and they were sharpened by the removal of burin spalls in the case of burins and by direct retouch for the end scraper. Edge sharpening is evidenced when use wear is interrupted by a new generation of retouch. Several generations of sharpening removals can also change the edge angle and its morphology (Jardón Giner and Sacchi 1994; Vaughan 1985). Sharpening aims at extending the duration of use of a tool or an edge by maintaining its efficacy, thereby delaying the tool's replacement.

Five of the 12 analyzed burins and nine of the 46 analyzed burin spalls show traces of use. The burins were used to scrape hard and semihard materials with the robust edges along the burin facets. The blank flake on which they were shaped was occasionally used prior to the burin spalls removal to scrape or cut semihard or hard materials. No burin tooth or burin bevel has evidence of use wear, and burins were therefore likely not used for grooving. The analysis of two refitted sharpening sequences shows that burin spalls can have similar use wear as the burin from which they were detached, demonstrating that sharpening—at least in those cases—probably aimed at extending the duration of use of an edge to perform a single activity (Figure 5).

Analysis of the end scraper indicates that it was used for dry hide scraping with its retouched distal end. The marginal extension of the edge rounding and its flat morphology indicate that the working angle was open (ca. 90°; Figure 6). In the ethnoarchaeological record (Beyries 2002; Beyries and Rots 2008; Shott and Weedman 2007), scrapers are sharpened to maintain an acute working edge that is

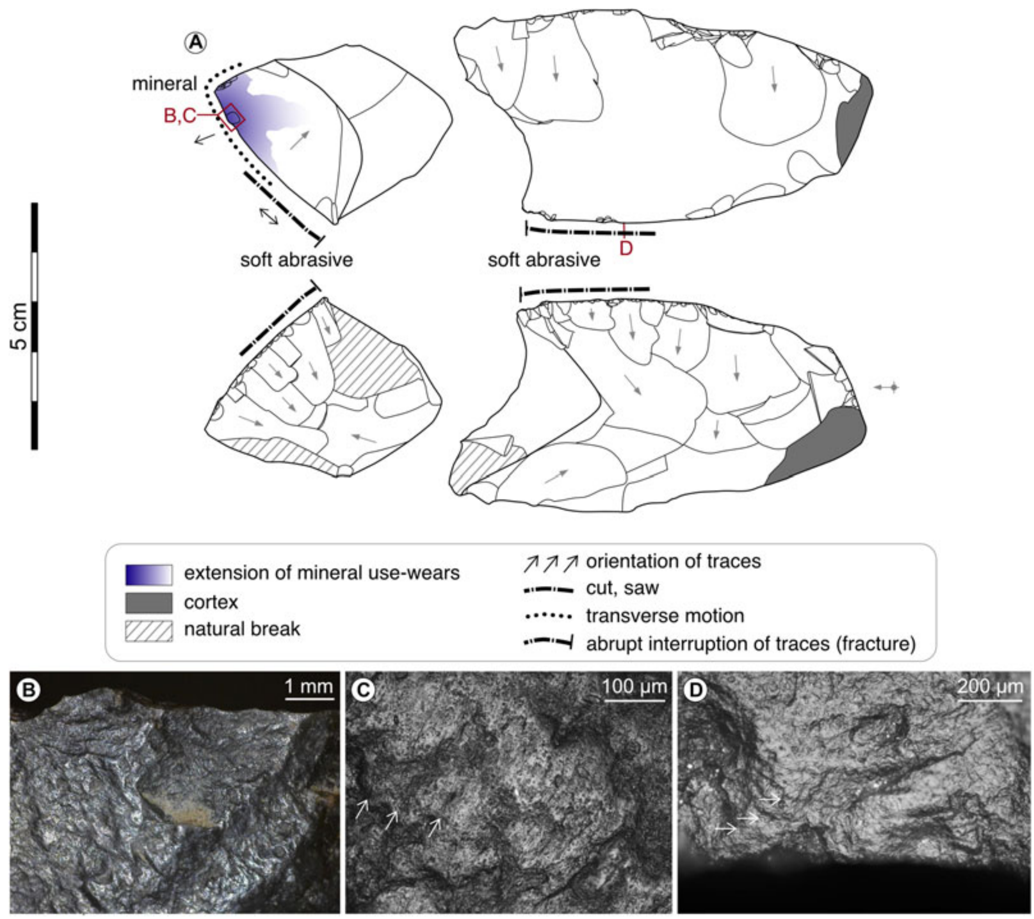

Figure 4. Bifacial preform with use wear: (A) refitted bifacial preform used to work mineral with its tip and to cut soft abrasive material with a long ridge; (B, C) mineral wear with abundant striations; (D) rounding and striations parallel to the edge related to cutting soft material. (CAD by Eugénie Gauvrit Roux.) (Color online)

efficient when removing material from a hide (e.g., hair, grease, epidermis). Consequently, the archaeological end scraper is consistent with dry hide defleshing, shaving, or thinning.

The Question of Transport

Mechanical alteration is light on the assemblage (Supplemental Figure 2), but 32 pieces suffered mechanical damage *before* the opening of the striking platform and the removal of the ski spalls (platform rejuvenation flakes), ridge spalls, crested blades, and microblades for cores; before the removal of burin spalls for burins; and before the retouch of the distal edge for the end scraper. The ridges of the negatives from the shaping out removals are intensely rounded and shined, whereas the final removals have the same unaltered aspect as the rest of the lithic assemblage (Table 1; Figure 7). This pattern of traces may correspond to recycling of previously altered pieces or to transport or storage of flakes and microcore preforms followed by their shaping or knapping. Transport to the site or storage at the site are more likely if we consider the recurrence of traces on specific categories of pieces (tools on flake and microcores) and the technological organization of rounding and shine. They show that the mechanical alteration occurred before the retouch of flake tools, and before the knapping phase of bifacial preforms. Many of the core preforms were then knapped at the site, judging by the numerous refittings of by-products of the microblade production. The refitting study and the representation of the different categories of by-products and finished products of the microblade production per rock

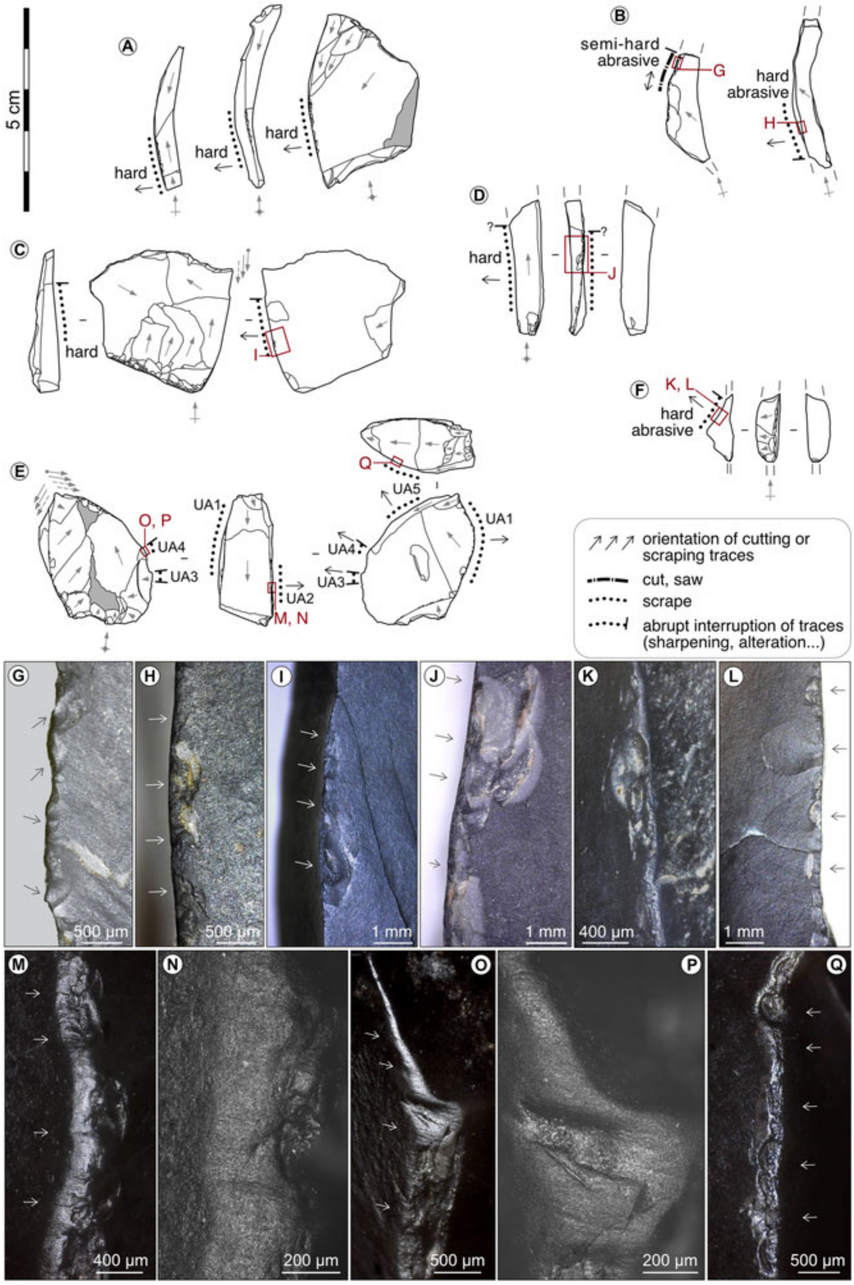

Figure 5. Used burins and burin spalls: (A) burin and two refitting sharpening spalls used to scrape hard material; (B) refitted burin spalls; the first spall was used to cut semi-abrasive material, and the second was used to scrape hard material; (C) burin used to scrape hard material; (D) burin spall used to scrape hard material; (E) burin with five different UA; UA1, UA4, UA5: scraping semihard abrasive material; UA2: scraping hard abrasive material; UA3: scraping semihard or soft abrasive material; (F) burin spall used to scrape hard abrasive material; (G) scars with oblique orientation and light rounding related to cutting semihard abrasive material; (H, I, J) scars perpendicular to the edge related to scraping hard material; (K, L) scars perpendicular to the edge and moderate rounding related to scraping hard abrasive material; (M, N) intense rounding, shine, and striations perpendicular to the edge with altered microwear related to scraping hard abrasive material; (O, P) intense rounding shine and striations perpendicular to the edge with altered microwear related to scraping semihard abrasive material; (Q) scars perpendicular to the edge and moderate rounding related to scraping semihard abrasive material. (CAD by Eugénie Gauvrit Roux.) (Color online)

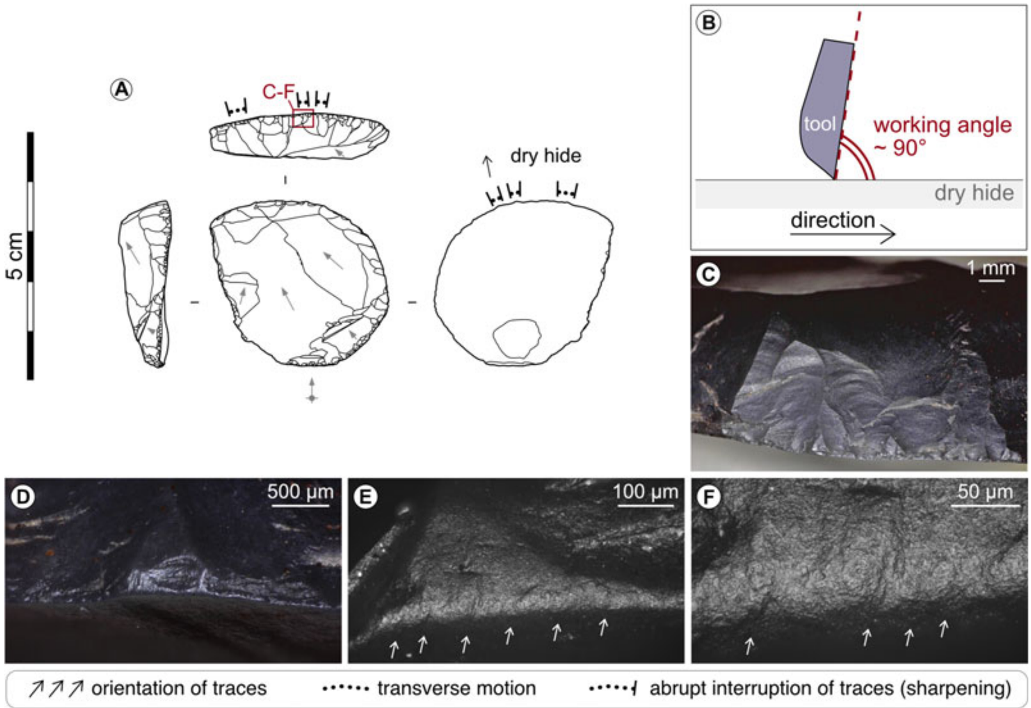

Figure 6. Used end scraper: (A) end scraper used to scrape dry hide and sharpened; (B) restitution of the scraping motion based on the rounding organization; (C) retouch with several generations of removals due to edge sharpening; (D) intense rounding of the working edge; (E, F) rounding, striations perpendicular to the edge, and irregular and dull polish related to dry hide scraping. (CAD by Eugénie Gauvrit Roux.) (Color online)

type besides indicates that bifacial preforms were not all shaped at the site. For example, a rhyolite microcore without refitting shaping flakes was likely shaped outside the site, and some microblades made of siliceous rocks were likely introduced at the site as finished products because no matching core or by-products for these raw materials were recovered.

Evidence of transport of microcores and flakes is found in numerous sites through raw material procurement analysis (e.g., Gore and Graf 2018; Kuzmin et al. 2008; Sano 2007), and it is suggested by observation of wear on obsidian pieces at Nogahabara I (Odess and Rasic 2007), Campus, and Chugwater (Gómez Coutouly 2017) in Alaska. It is also demonstrated through the traceological analysis of pieces made of effusive rock at Kovrizhka IV in Siberia (Gauvrit Roux et al. 2021; Teten'kin et al. 2016). The transport or storage of pieces to constitute reserves of raw material may be related to long-distance procurement of tool stone, to the high mobility of hunter-gatherers, and to the difficulty of accessing or seeing raw material sources due to thick snow cover and polar nights that lasted for several months a year.

Discussion

A Brief Occupation?

The *chaîne opératoire* (Figure 8) reveals partial segmentation in time and space of microblades production and use, which could be related to important mobility of human groups. This interpretation is consistent with the brief occupation at Swan Point and the archaeological record of Siberian Dyuktai sites, which so far are mostly represented by short occupations, revealing highly mobile hunter-gatherer societies (Goebel 2002).

Lithic techno-functional analysis shows that the proportion of tools with use wear is low; tools generally have short biographies with only a few sharpened or reused tools and often weakly developed traces. These data could indicate a brief occupation, a specialized use area in a larger site, or evidence the general techno-functional features of Yubetsu sites in Alaska. It is worth considering

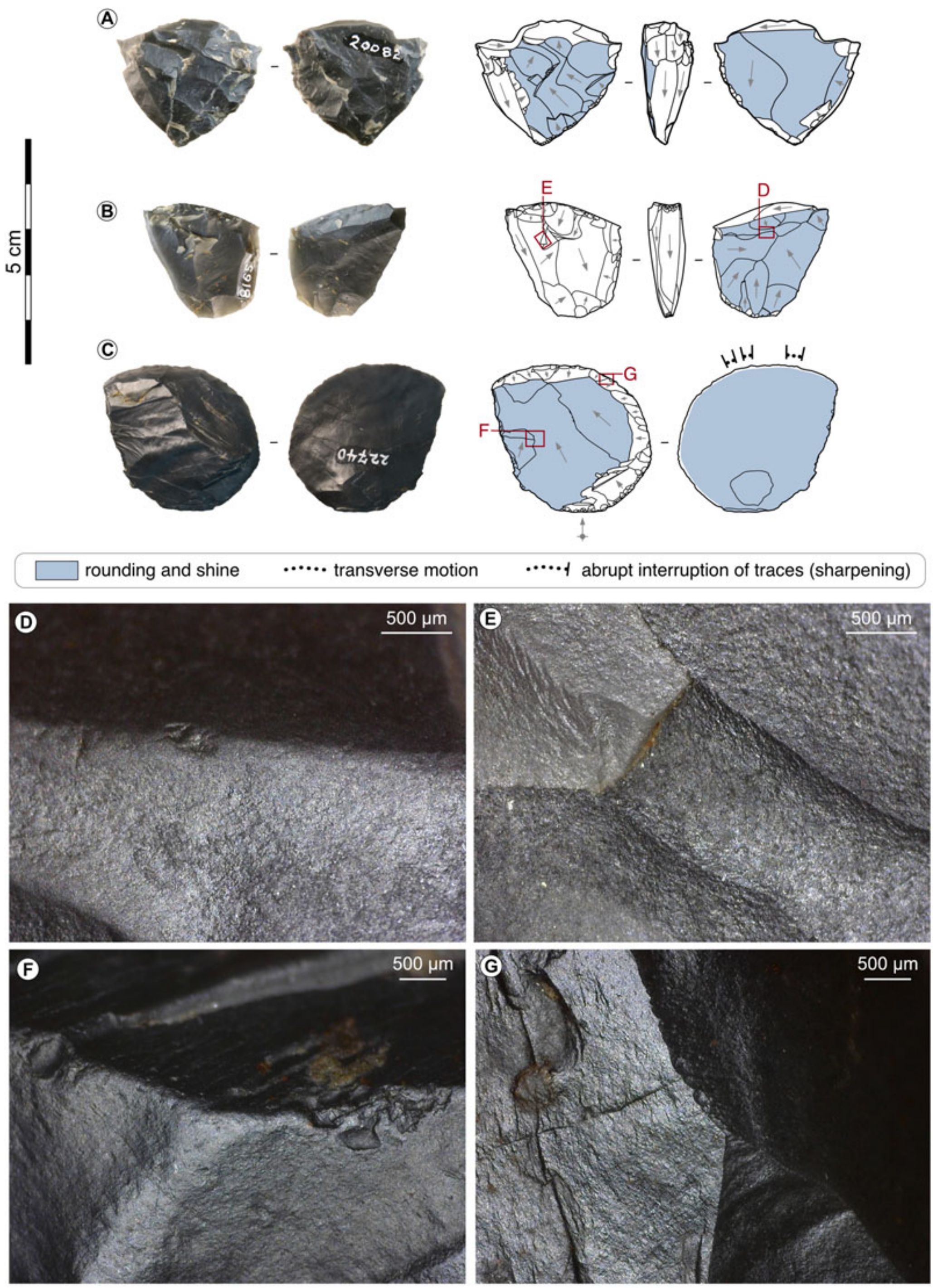

Figure 7. Potentially transported pieces: (A) Yubetsu microcore with rounding and shine on the shaping removals; the flaking surface and the striking platform are unaltered; (B) burin/microcore with rounding and shine on the shaping removals of one face; (C) end scraper with rounding and shine on the flaking surface; the retouch removals are unaltered; (D, F) rounding and shine of arises; (E, G) unaltered arises. (A, B, C) Pieces made of silicious rocks. (CAD by Eugénie Gauvrit Roux.) (Color online)

that the site possibly extended beyond the excavated area, but none of the test pits around it yielded material associated with the CZ4b component. So far, multidisciplinary data support the idea that CZ4b was a brief occupation: (1) the ^{14}C dates are centered on 14,000 cal BP (Supplemental

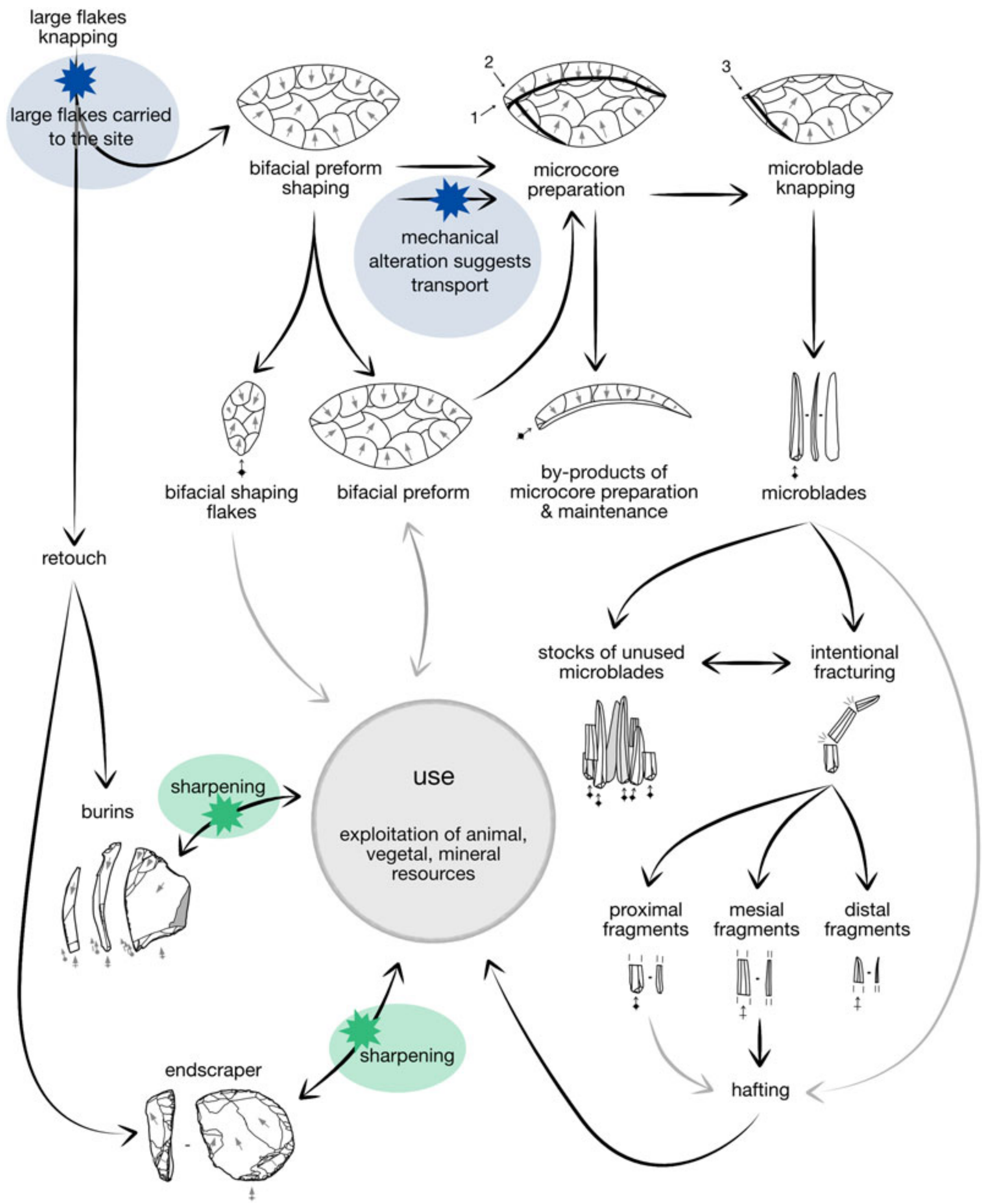

Figure 8. *Chaîne opératoire* of microblade production and use. (CAD by Eugénie Gauvrit Roux.)

Table 1); (2) lithic raw materials are not very diversified compared to other levels of Swan Point and most Late Pleistocene contexts of central Alaska (Hirasawa and Holmes 2017); (3) lithic technology demonstrates that microcores and microblades have a very homogeneous morphologic and volumetric conception, and that the retouched tools are quite rare; and (4) the abundant refits between lithic and fauna concentrations associated with the two hearths suggest that they were used simultaneously and likely correspond to a single event (Gómez Coutouly and Holmes 2018; Lanoë and Holmes 2016; Potter et al. 2013). Activities evidenced through use-wear analysis include repairing damaged hunting weapons and composite knives by producing lithic inserts, replacing the used ones, manufacturing and possibly repairing and replacing osseous or wooden hafts, scraping hard materials that

Table 3. Comparison of Microblades Use in Northeast Asia and Northwest North America.

Country	Region/ State	Site	Level/ Concentration	Age	Microblades Production Method	Retouch of Microblades	Use of Microblades					Reference
							Cut	Scrape	Perforate	Projectile Insert	Hafting Traces	
USA	**Alaska**	Swan Point	CZ4b	ca. 14,000 cal BP	Yubetsu	very rarely backed	X[a]	X	—	X	—	This study
Russia	**North Baikal**	Kovrizhka IV	6	ca. 19,000 cal BP	Saikai (Yubetsu variant)	no	X	—	—	X	—	Gauvrit Roux et al. 2021
	Kamchatka	Ushki Lake I–V	VI	ca. 13,000–12,000 cal BP	Yubetsu	no	X	X	—	—	—	Dikov and Kononenko 1990
Japan	**Hokkaido**	Tachikarushunai V	point C	Late Glacial	Yubetsu, Horoka	occasionally backed	X	—	—	?	X	Kanomata 2005
		Oruika 2	block 3	ca. 18,000–15,000 cal BP	Sakkotsu (Yubetsu)	no	—	—	—	—	X	Kanomata 2013
		Yoshiizawa	BL2A, BL2B	ca. 18,500–17,500 cal BP	Oshorokko (Yubetsu variant)	no	—	?	—	—	—	Iwase et al. 2016
		Kamihoronai-Moi II	—	ca. 19,000–18,000 cal BP	Yubetsu	no	—	—	—	—	X	Takase 2008
		Pirika loc. A	Sb 1-3, 4, 11	ca. 25,000–23,000 cal BP	Rankoshi, Togeshita	no	X	X	—	—	—	Gauvrit Roux 2024
		Obarubetsu 2	V	ca. 25,000–24,000 cal BP	Rankoshi	no	—	—	?[b]	X	—	Iwase 2021
		Kashiwadai 1	LC 1, 2, 3, 6, 12, 14, 15	ca. 25,000 cal BP	Rankoshi	no	—	—	—	X	X	Iwase 2016
	Honshu	Araya	—	ca. 18,000–17,000 cal BP	Yubetsu	frequently backed	X	X	—	?	X	Kanomata 2005
South Korea		Hopyeong-dong	layer 2 Southwest sector	ca. 28,200–18,500 cal BP	bifacially prepared cores; Saikai (Yubetsu variant), Yubetsu	occasionally appointed	X	X	appointed microblades	—	—	Kononenko 2008

[a]X = presence
[b]? = probable presence, according to the authors

Figure 9. Osseous points with microblades fragments in the slot. Bol'shoi Iakor' I, level 6 (Vitim Valley, Eastern Siberia), circa 14,000 cal BP, associated with the Yubetsu method. (After Ineshin and Teten'kin 2017; Photograph courtesy of Aleksei V. Teten'kin.) (Color online)

may be osseous with the burin facets, cutting and scraping dry hide, and butchering with the microblades. Part of these activities may have been performed outside the site given that archaeozoological data show that manufacturing and repairing tools probably played an important role during the occupation of the site. Ivory and bone remains exhibit a diversity of processing techniques (percussion, grooving, splintering, scraping, abrading), and these remains mainly have a low nutritive value (e.g., mammoth tusk ivory, swan wings), which suggests their use for non-nutritive technical activities (Lanoë and Holmes 2016).

Design and Economy of Composite Tools

Hafting traces were identified on obsidian microblades from the Hokkaido Island in Japan (Table 3), and despite the absence of clear hafting traces on microblades at Swan Point CZ4b, it is likely that these tools were hafted given that their small size makes handling difficult. In Beringia, several findings of Late Pleistocene osseous elongated slotted pieces (for example, Trail Creek Cave 2 in Alaska [Craig and Goebel 2016]) and occasionally still hafted with microblades like at Bol'shoi Iakor' I in Siberia [Ineshin and Teten'kin 2017] show that (1) microblades were positioned laterally, juxtaposed, with the length parallel to the haft; and (2) there were typically multiple (and up to about 50) lithic inserts hafted per composite tool, whether for knives or projectiles (Figure 9). The insertion of microblades in the narrow and deep slots of the osseous hafts probably constrained the curvature and the thickness of tools, leading to the exclusion of part of the blanks and the distal fragments. The strict morphological selection of pressure microblades was therefore likely correlated to hafting constraints. The preferential localization of cutting and scraping traces on the left edge of microblades may also indicate preferential lateralization of the lithic inserts on the knife handles (i.e., proximal part of microblades preferentially oriented toward the knife tip or away from it).

So far, we cannot ascertain that the projectiles to which microblades were hafted were either shot with a spear-thrower, a bow, or manually given that (1) there is an important overlapping of the tip dimensions of projectiles shot with a bow or a spear-thrower, and of the dimensions, morphology, and quantity of impact damages on lithic inserts shot with a bow or a spear-thrower (Cattelain 1994; Cattelain and Perpère 1996); (2) impact damages are generally uncommon in the microblade assemblage (Table 2), which does not allow detailed ballistic interpretations; and (3) no wood or osseous point contemporaneous to Swan Point CZ4b is preserved in Alaska. The earliest known remains come from Trail Creek Cave 2 in Western Alaska, circa 11,500 cal BP, and they are incomplete (Craig and Goebel 2016). The archaeological record of the ice patches of northwestern North America yields elements related to atlatl technology (wood dart shafts and tips) dating back to approximately 9000 cal BP (Gladstone, Yukon, Canada; Hare et al. 2004, 2012), and the earliest bow remains date back to around 1200 cal BP (Alligator, Yukon, Canada; Hare et al. 2004, 2012). This suggests that the bow-and-arrow technology was uncommon or even absent until the Late Holocene traditions in Eastern Beringia, and that before that, hunting was probably performed essentially with spear-throwers and darts—or also (because it cannot be excluded thus far) with hand-thrown spears.

Lateral lithic inserts are located away from the penetrating point of projectiles, and they mostly aim at lacerating the prey. Experiments show that few impact fractures develop on these inserts because they are distant from the impact point, as opposed to inserts positioned axially (i.e., as points), which absorb most of the impact stress and often fracture (Chesnaux 2014; Gauvrit Roux et al. 2020; Pétillon et al. 2011; Wood and Fitzhugh 2018; Yarosevitch et al. 2010). Consequently, it is probable that a higher number of microblades was involved in the hunting activity but were not fractured on impact and remain undetectable. Nonetheless, the low rate of microblades with use wear, the generally weakly developed traces, the near absence of retouching, and the absence of sharpening suggest that they were relatively ephemeral tools with short biographies.

It appears that microblades were often replaced by new ones on the haft, even if their edge was not totally worn out. In this context, microblade standardization allowed fast and easy maintenance of composite tools because lithic inserts were interchangeable. The systematic low rate of used microblades in the Late Pleistocene sites suggests that both the strict selection of certain morphologies of microblades (with discard of the nonviable products) and the overproduction to constitute stocks of useable blanks were widespread features of the tools' economy for sites with a pressure microblade component, both in Northeast Asia and at Swan Point CZ4b in central Alaska.

Large-Scale Versatility of the Late Pleistocene Microblades

Microblade production is a structuring element in Beringian Late Pleistocene archaeology, and use-wear analysis offers a better understanding of the status of final products and by-products through defining their technical purposes throughout the production process. This functional study also refines our comprehension of the success of microlithization in cold environments (Elston and Kuhn 2002; Goebel 2002; Wygal 2011). Traceological data reveal that the technology of microblade pressure knapping is not related to a functional specialization at Swan Point but rather to a broader flexible use. In fact, comparisons with data from Late Pleistocene sites in Japan, Korea, Siberia, and from Swan Point reveal that these tools were relatively versatile: they were mostly used for cutting/sawing actions with a lateral edge, and they were also occasionally used as projectile inserts, to scrape with a lateral edge and to perforate with an extremity (Table 3). The broad range of tasks involving microblades (butchering, hide cutting and occasional hide scraping, wood and osseous working, and hunting) is not represented at each site, and this likely reveals that the function of microblades varied according to the site function. Because of this intra- and intersite variability, it is impossible to generalize about microblade function. Use-wear data for Late Glacial microblades are scarce and do not yet allow us to observe a possible regional and chronological pattern of functional variation. So far, data instead tend to indicate that the functional versatility of microblades remains a constant, regardless of the region, the chronology, and the production method considered—that is, throughout the diversity of environments in which this innovative toolkit spread. But to verify if this reflects an archaeological reality, it will be necessary to systematically question the functional roles of these tools on both sides of the Bering Strait.

Conclusion

Early microblades of Alaska were multipurpose tools (used as knife and projectile inserts) and ephemeral tools (the absence of sharpening and the often weakly developed traces indicate their short lifespans), and this renews the understanding of this toolkit, which so far is mostly seen as being specifically dedicated to the hunting activity. Our data also show that the microblade pressure-knapping technology is related to an economy based on the planning of future needs, which is visible through (1) the production of bifacial microcore preforms that can be both tools and cores; (2) the possible transport of bifacial microcore preforms and flakes, which enables differing production and use of microblades and by-products in time and space; (3) the standardization of microblades and their overproduction, which ensure fast and easy replacement of lithic inserts; and (4) the relative versatility of microblades, which allows responding to various needs. This technological ability to anticipate future needs and therefore minimize risk (Elston and Brantingham 2002) through characteristics such as portability, versatility, maintainability, and reliability (Bleed 1986; Kuhn 1994) is probably one of the keys to understanding the human ability to settle in the cold environments of Alaska and Siberia at the end of the Last Glacial. The microblade system was, however, not only organized toward economical optimization but also answered to social and symbolic parameters, which are essentially inaccessible today. They may have largely conditioned the organization of the lithic system from tool stone procurement to the use and discard of tools, because the needs of human groups are not exclusively defined by environmental constraints but also—and possibly primarily—by the cultural context (Pfaffenberger 1992).

This study offers the first techno-functional keys to understanding the Alaskan microblade system and provides a basis for further comparisons. Extensive functional comparisons are indeed needed to approach the techno-economical behaviors of societies in subarctic environments in more detail and determine how they varied in time and space. For instance, in Alaska, the Campus method (i.e., pressure knapping on thick flakes that are unifacially shaped) becomes the main method for microblade production from 12,500 cal BP as part of the Denali complex, and it occasionally is associated with the production of Chindadn bifacial points (Holmes 2008). This shift from the Yubetsu method to the Campus method has previously been interpreted as an adaptation to the availability of raw materials in Alaska (Gómez Coutouly 2012; Gómez Coutouly and Holmes 2018). But at the dawn of the major environmental changes of the Holocene, it must be considered that the modalities of exploitation of animal, vegetal, and mineral resources changed, too. This underlines the necessity of a systemic and transdisciplinary reflection on the potential correlation between changes of environments, exploitation strategies of raw materials, modes of production of tools, and toolkits functioning between the Pleistocene and the Holocene in Alaska. Use-wear analysis has a key role in this regard, because it permits linking the stone tools with the different resources exploited by past societies. Comparing the modalities of implementation of tools between sites should make it possible to follow techno-economical transformations at a key moment of the peopling of the American continent.

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Data Availability Statement. The Swan Point collection is currently housed at the University of Alaska Museum of the North in Fairbanks.

Competing Interests. The authors declare none.

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Supplemental Table 1. AMS radiocarbon dates of Swan Point CZ4b. Calibration OxCal v4.4.4 Bronk Ramsey 2021; r:5; Atmospheric data from Reimer et al. 2020. 2σ. Calibration curve IntCal 20.

Supplemental Table 2. List of pieces with use wear at Swan Point CZ4b.

Supplemental Figure 1. The Yubetsu method. Modified after Gómez Coutouly and Holmes 2018.

Supplemental Figure 2. Intensity of different types of alteration per raw material. Pieces with possible transport traces excluded. Gradients of intensity detailed in Gauvrit Roux and Fernandes 2022.

Supplemental Figure 3. Examples of postdepositional alterations and nonanthropogenic residues: (a) bright spot; (b) fresh scar; (c) iron oxide deposit on a flake that does not show use wear; (d) iron oxide deposit and ashy deposit on a microblade that does not show use wear.

Supplemental Figure 4. Fracture types. Modified after Gauvrit Roux et al. 2020.

Supplemental Figure 5. Distribution of the dimensions of 412 unretouched microblades with and without use wear.

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