AN ANALYSIS OF DENBIGH FLINT COMPLEX BURIN TECHNOLOGY FROM MATCHARAK LAKE, ALASKA

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ABSTRACT

This paper presents the results of an analysis of burins and burin spalls recovered from a 3,900-year-old frozen Denbigh Flint Complex midden discovered in Arctic Alaska. Use-wear patterns along with preserved organic remains suggest burins were used not only as gravers, but also as scrapers on bone, antler and wood. Additionally, some of the burins served as cores for producing spalls that were also used as engraving tools. Statistical tests suggest only larger spalls were selected for engraving tasks. An experimental study shows spalls must meet minimum thickness requirements to avoid fracture upon use. Experimental findings of burin spall use show they are suitable for performing the engraving tasks observed on decorated bone tools discovered at the Matcharak Lake Site (AMR-186).

KEYWORDS: Arctic Small Tool tradition, Denbigh Flint Complex, burin technology, stone tool function, use wear analysis, experimental archaeology

INTRODUCTION

This study presents a functional analysis of burin technology from a 3,900-year-old Denbigh Flint Complex site, Matcharak Lake site AMR-186, located in the central Brooks Range of Alaska (Fig. 1). The Denbigh Flint Complex is a distinctive regional tool classification of a northwestern variant of the widespread Arctic Small Tool tradition (ASTt) (Odess 2005). Burins, particularly the "mitten-shaped" or "stacked step" burins, are a highly diagnostic tool type found in Denbigh sites across the Arctic (Bandi 1963; Gal and Hall 1982:4–5) (Fig. 2). Excluding the pioneering work of Giddings (1956) and Bandi (1963), relatively little work has been done to explain the manufacturing techniques of these tools or their function in Denbigh culture. Generally, burins and burin spalls are interpreted as engraving implements used for the manufacture of organic tools (Bandi 1963; Giddings 1956; Sutherland 1996). Some have explicitly linked burins in arctic cultures to microblade technology, suggesting they were predominantly used to incise antler projectiles for inserting microblades (Anderson 1968). A lack of organic preservation at Denbigh sites precludes evidence of such activities (Bandi 1963; Odess 2005).

With no organic tools found associated with the Denbigh Flint Complex, interpretation of burin and burin spall function was based on analogy and speculation. However, Matcharak Lake (AMR-186) provides researchers with new organic evidence that allows us to test some of the assumptions and proposed uses made by Giddings and others. This study uses the recovered burins and burin spalls from Matcharak Lake to identify wear patterns showing how the tools were utilized, in addition to experimental observations which test the hypothesis that burins were used to make engravings and cuts observed on faunal remains recovered from AMR-186. This paper expands on our current understanding of burin technology and the burin blow technique in Denbigh culture by sup-

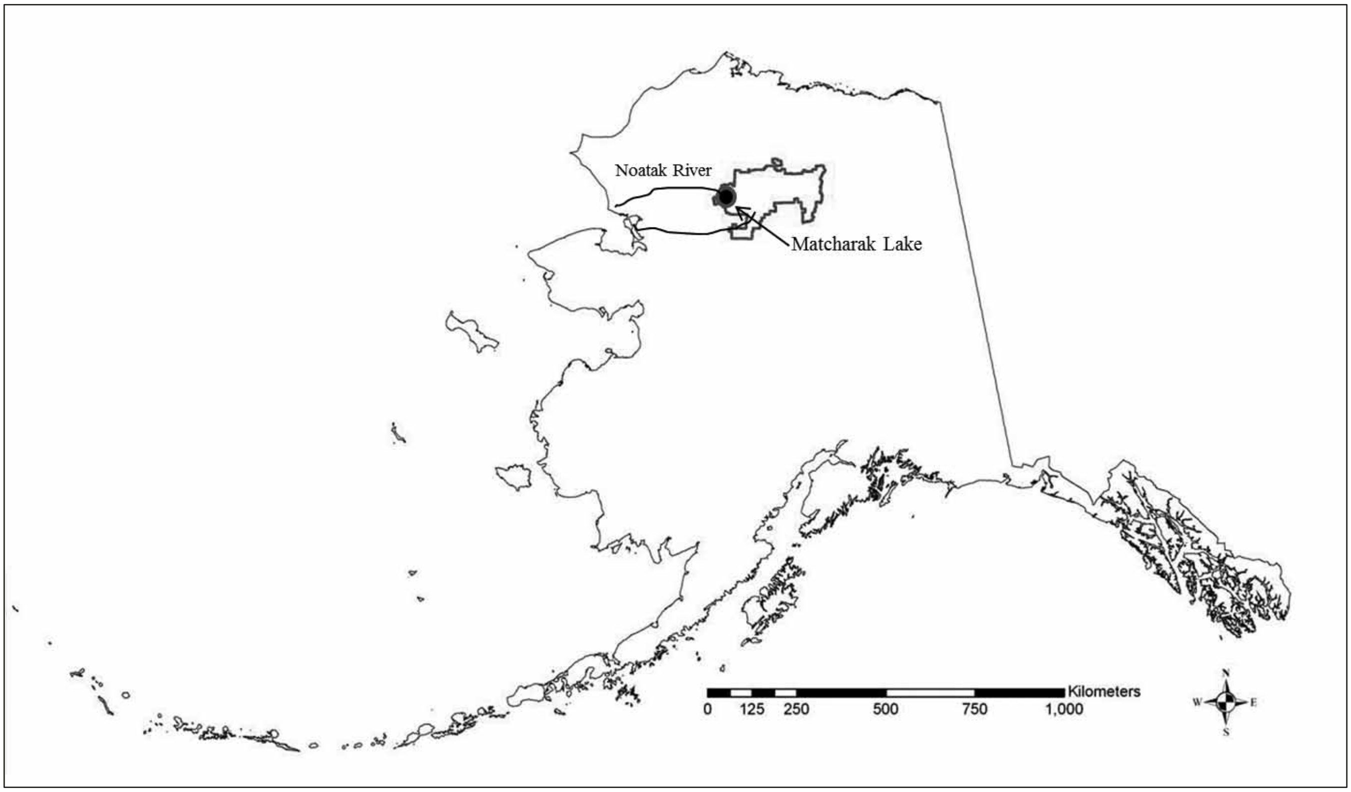

Figure 1. Gates of the Arctic National Park and Preserve and the area of study, the Upper Noatak River

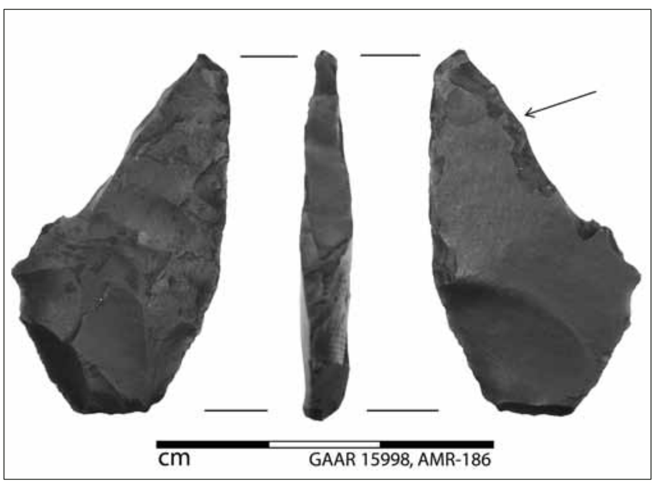

Figure 2. The diagnostic "mitten-shaped" burin of the Denbigh Flint Complex

porting long-held hypotheses about the function of these tools—for engraving and shaping organics and as cores for burin spalls; and by documenting previously unrecognized uses, such as scraping or whittling, and as hafting elements, serving as basal modification for fitting into an existing haft. These data are important for understanding the role that burins play in the technological organization of Denbigh tool kits. With an expanded functional role we should expect to find burins in a variety of camp types throughout all seasons of the year. While this study does not provide an intersite analysis this paper does present the information needed for such comparisons.

A BRIEF SUMMARY OF BURIN STUDIES

The study of burins has a long history in archaeological lithic analysis, from typological classification focused on morphology (Clay 1976; Noone 1934; Pradel 1971) to functional studies focused on manufacture and use (Barton et al. 1996; Kay and Solecki 2000; Stafford 1977; Tomaskova 2005; Vaughan 1985). The results of these studies show that burin technology is more complex and diverse than initially realized. Burins are defined by a specific flint-knapping technique for removing a linear spall of stone, known as the burin blow (Vaughan 1985). The removal of the spall from a biface or flake margin creates a sharp, nearly 90-degree beveled edge that ends with a chisel-like tip. Early interpretations of burin function suggested they were tools for engraving bone or antler (Barton et al. 1996; Giddings 1956). This interpretation was taken for granted as researchers focused predominantly on typological classifications of various burin forms (Noone 1934). However, archaeologists now understand burin technology to be much more variable and versatile. Barton et al. (1996) argue that burins and the burin blow spall removal technique were used for a number of purposes, including: engraving, as a scraper edge, to rejuvenate a scraping edge, for the shaping of haft elements and as a core for producing burin spalls, which may then be used as tools themselves. Other studies have focused on use-wear with the explicit goal of determining the material the burin was used on, as another means of deriving function and durability of burins made of different raw materials (Kay and Solecki 2000; Stafford 1977). Another study involved a burin refit analysis to understand burin production, and human behavior, as well as site formation and disturbance processes (Cahen et al. 1979). Each study has furthered our understanding of this enigmatic technology, yet many questions remain concerning idiosyncratic uses in different cultural traditions.

Burin technology of the Old World can be traced as far back as 28,000–33,000 years ago (Kay and Solecki 2000). Burins were present across Europe during the Upper Paleolithic (Tomaskova 2005) and in many of the oldest sites in Beringia (Irving 1955; West 1996). Whether or not this technology spread east from Europe or was independently invented is debatable. Outside of arctic North America, burin technology is not widespread in the New World (Epstein 1963; Gibson 1966). Compared to the Old World and the Arctic, burins are rare in prehistoric North America. Burin technology is commonly co-occurs with microblade technology, which implies a greater reliance on organic tools. These technologies are similar in that they produce long, narrow, uniformly shaped flakes that are removed by pressure or a controlled punch. In arctic microblade traditions, the burin is thought to be used to make incisions in bone and antler points, which are then inset with microblades (Anderson 1968). However, as argued for Old World examples, burins served more than one function: as engravers, scrapers, hafting elements, and cores (Barton et al. 1996).

SITE BACKGROUND

The Matcharak Lake Site (AMR-186) was discovered in 2007 and was test excavated in 2008 and 2009 by National Park Service archaeologists (Tremayne 2010). Excavation of 22 m^2 led to the discovery of dozens of diagnostic Denbigh artifacts including end blades, side blades, burins and microblades along with thousands of ecofacts and faunal specimens preserved in frozen soil. Ten radiocarbon dates from bone and charcoal recovered from Matcharak Lake average 3583 (±40) radiocarbon years BP, indicating one or two fairly discrete occupations occurred around 3730–3980 cal BP, contemporaneous with other "Classic Denbigh" sites in Alaska (Tremayne 2010). The Matcharak Lake Site (AMR-186) is a uniquely well preserved Denbigh camp which produced over eighty thousand faunal specimens, predominantly caribou. A faunal analysis identified Dall sheep, porcupine, arctic ground squirrel, Alaska marmot, snowshoe hare, willow ptarmigan, Anatidae, and four species of fish (Tremayne 2010). Based on juvenile caribou remains and migratory bird bones, the occupation(s) at Matcharak Lake occurred in the late summer, fall and in the spring (Tremayne 2010). There is no solid evidence for winter occupation, although it cannot be ruled out. Some of the only known Denbigh organic tools are included in the preserved remains. Four bone points or awls were recovered and one decorated bone foreshaft. A number of cut pieces of antler and bone waste products were recovered as well, preserving evidence of organic tool manufacturing processes. The foreshaft specimen exhibits three parallel incised grooves, apparently meant to be decoration (Fig. 8). These designs constitute the only known artwork by Denbigh people, with the Trail Creek cave finds as a notable, ambiguous exception (Larson 1968) In addition to the information on Denbigh diet, camp function and seasonality, the recovered faunal material allows researchers to link tool types to subsistence strategies that may vary between camp type or seasonal rounds. Use of specific tools may be found to correspond with certain activities. Lacking a local stone source, Denbigh people at Matcharak Lake were very conservative with raw material, which may have influenced use of other tool types, such as burin spalls.

DENBIGH BURINS

Denbigh Flint Complex burin technology is distinctive and varied. Giddings (1951) recorded a variety of burin types from the Denbigh type-site Iyatayet, located on Cape Denbigh. Giddings recognized the single faceted transverse and oblique burins ("mitten-shaped"), a beaked burin, the double faceted burin, separated and convergent burins, the double end burin and a burinated microblade (Giddings 1964). Gal and Hall (1982) introduce the term "stacked step" burin to replace the "mitten" or Denbigh burin, to set this tool apart from the other burins found in Denbigh tool kits; however the term "mitten-shaped" is still commonly used to refer to this diagnostic burin type. At Matcharak Lake we recovered fourteen total burins; ten "mitten-shaped" single-faceted burins and three single-faceted scraper burins (Fig. 3, #15988, 15677, and 16593). We also recovered one scraper burin, double faceted at the base and single faceted at the presumed tip (Fig. 3, catalog #16292). One mitten shaped burin may be an end blade with a burin blow on the base to produce a hafting element (Fig. 4, catalog #15998), discussed further below. The lack of diversity in burin types at Matcharak Lake compared to Iyatayet may reflect a simplification of the tool kit for terrestrial hunting as maritime hunting strategies require more complex technology (Collard et al. 2005:3).

Seven of the burins from Matcharak Lake are made of black chert, four from gray chert, one from green chert and two from obsidian. There seems to be no preference between black and gray chert for the type of burin made. The black chert tends to exhibit polish towards the tip that is not present on the gray pieces, although it may just be harder to detect with gray chert. The obsidian burins are unusual in that they do not have multiple spalls removed, nor do they exhibit any evidence of use. Some may consider these to be gravers rather than burins.

I focused my attention on the chert "mitten-shaped" burins for the following analysis. A low-powered 10–50x microscope was used to observe all burin edges, the burin tip and the burin facet edge for evidence of use-wear. Additionally, I noted any residue present on the tools. I recorded the number of spalls that were removed for each burin and whether it was complete or fractured. All of the burins have use-wear on the distal tip or the burin stem. Four of the ten "mitten-shaped" burins have evidence of use in the form of tiny retouch or edge damage along the margin of the burin stem (Figs. 2, 10). The mitten-shaped burin is made on a linear flake that was subsequently unifacially flaked along the dorsal side. The ventral side is unmodified or only lightly flaked along the margins. Once the unflaked ventral side of the burin is used it creates unmistakable use-wear in the form of polish and striations (Fig. 9). For the dorsal side, use may have occurred, but it is difficult to differentiate between use-wear and intentional or remnant flake scars. Rejuvenation of the edge by a burin blow as a reductive or "creator" technique (Vaughan 1985) occurred at least eight times, as use-wear was recorded at this position on eight of the seventy burin spalls examined. This indicates occasional use and reuse of the burin stem edge as a scraping or whittling tool. Exactly what material the burin edge was used to work is unclear, but preserved organics indicate bone and antler were shaped into pointed barbs or awls, and preserved wood shavings indicate that wood working occurred. Qeqertasussuk, a frozen ASTt site in Greenland, contemporaneous with the Matcharak Lake occupation, shows Saqqaq people heavily relied on wood in their toolkits (Grønnow 1996). Denbigh people likely did, as well.

This leads to a related research question: Were the burins from Matcharak Lake hafted? Considering the relationship between the ASTt people of Greenland to those in Alaska it seems reasonable to presume Denbigh people also shared some of the hafting techniques of the Saqqaq discovered at Qeqertasussuk (Grønnow 1996). A "mitten-shaped" burin was found at Qeqertasussuk still in its wooden, single slotted haft, bound with baleen (Grønnow 1996:21). While no wooden or bone hafts were recovered at Matcharak Lake, I did examine the basal edges of the "mitten-shaped" burins for edge grinding and notching. Microscopic analysis shows three of the burins were edge ground. There also appears to be intentional flaking to create a small step or tiny ridge present on all "mitten-shaped" burins, which may function as the top of the hafted base, similar to examples noted at other early ASTt sites in eastern Canada (Sutherland 1996:276). Furthermore, under the low-powered microscope, I observed fibers that may be remnant sinew and red ochre staining on three burins. Red ochre was commonly used as hafting adhesive in stone tool technologies around the world (Wadley 2005), and its presence here lends credence to the hypothesis that the "mitten-shaped" burin was a hafted tool in Denbigh toolkits.

Considering the recognition of the burin blow as a means for creating hafting elements in Paleolithic southwest Asia (Barton et al. 1996), we must also consider this as a possibility for two burins from the Matcharak

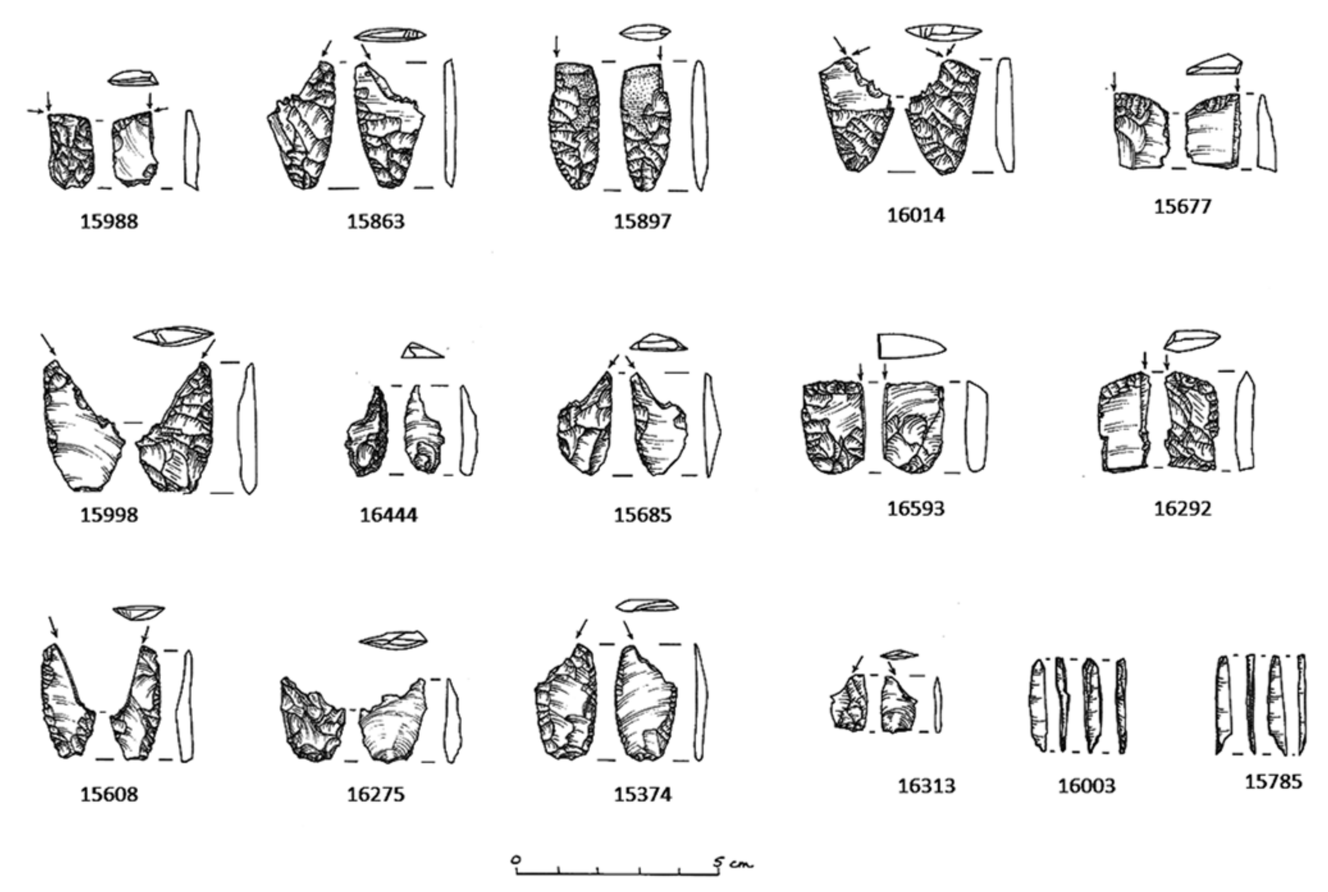

Figure 3. Illustrations of 14 burins and two representative burin spalls (lower right) collected from Matcharak Lake (AMR-186). Artifacts illustrated by Sarah Moore.

Figure 4. Burinated end blade or the start of a "mitten-shaped" burin.

assemblage (Fig. 3, catalog # GAAR 15897 and GAAR 16292). Burin 15897 could be viewed as a square based end blade or simply as a "mitten-shaped" burin with only one spall removed (Fig. 4). Grinding and polish along the margin implies that this is probably an early stage of burin production. Burins may have served as other tool types, such as flake tools, bifacial knives or end blades before burination occurred (Bandi 1963:24). Burin 16292 seems to have been burinated along the base to fit the tool to an existing haft or to repair damage.

In summary, the burins at Matcharak Lake are quite variable. They all have use-wear on the bit tip and 40% have wear along the stem margin suggesting scraping and whittling of organic material. The "mitten-shaped" burins were hafted tools that were resharpened with the spall removal technique numerous times. This tool type is generally argued to serve in the manufacturing of organic hunting implements (Sutherland 1996:278), a hypothesis supported here. The presence of burins at this camp suggests retooling and repair of organic tools occurred here.

While beyond the scope of this study, an intrasite spatial analysis is necessary to determine if burin presence or style varies with season or activity areas at Matcharak Lake.

BURIN SPALLS

A burin spall is a thin sliver of a flake produced from a burin blow (Fig. 5). Giddings (1964) describes the burin spall as an artifact similar to a microblade, except that it is square in cross-section, exhibiting four, nearly uniform sides (Fig. 3; catalog # 15785 and 16003). Some have argued that spalls are waste from rejuvenating a used edge on a burin (Vaughan 1985), while others argue that, in some cases, spalls are the desired product, burins serving as a core (Barton et al. 1996; Giddings 1956). Giddings (1956) established that the burin spalls produced by the Denbigh Flint Complex people were tools by identifying use-wear on the distal ends of the spalls. One should expect use-wear on the proximal end of a burin spall, as this is the bit of the burin, but not on the distal end, as this is still attached to the burin. Wear on the distal end of the spall can only occur after removal from the burin.

Burin spall use is a common attribute of Denbigh technology (Gidding 1964), but how and to what degree were they used at Matcharak Lake? What were they used on? Were they produced with specific attributes in mind, or are there a variety of spall sizes which can be used? To accomplish this analysis I created a spreadsheet in Statistical Package for the Social Sciences (SPSS) program to record and analyze a series of attributes relevant to the study. Recorded attributes include raw material type, completeness of the spall, length, width, thickness and weight. I used a low-powered microscope (10–50x) to identify evidence of use-wear and intentional retouch on the distal and ventral sides of the spall. I also recorded evidence of use-wear on the dorsal side of the spall as an indicator of use while still on the burin. I recorded any evidence of residues still present on the specimens and any possible evidence for the hafting of these tiny artifacts. Newcomer (1976) calls attention to the possibility of "spontaneous retouch" on the distal ends of the spalls. To differentiate between intentional use, retouch, and natural breakage, only spalls with multiple flake scars and polish on the tip were considered utilized. After confirming that some burin spalls were used, a series of statistical tests were employed to better understand selection of spalls for use.

The identification of use-wear on the distal end of the burin spall is not as straightforward as one might presume. Even under a microscope it can be difficult to distinguish between "spontaneous retouch" produced through removal of the flake (Newcomer 1976) and intentional retouch produced from use or resharpening of the tool. By looking at the jagged step fractures on the burin, it is apparent that some material is left behind, as the break is not clean (Giddings 1956:229) (see Fig. 2). On the distal end of the burin spall this "fracture" is often represented by a step, found on the dorsal side of the spall (Fig. 6a). This step creates a thin point which seems to be the preferred section of the spall to use, likely for engraving, as will be discussed below. To distinguish between natural and intentional breakage, I recorded whether or not the break was clean (Fig. 7a, b), if there were multiple flake scars

Figure 5. A representative sample of utilized burin spalls collected from AMR-186.

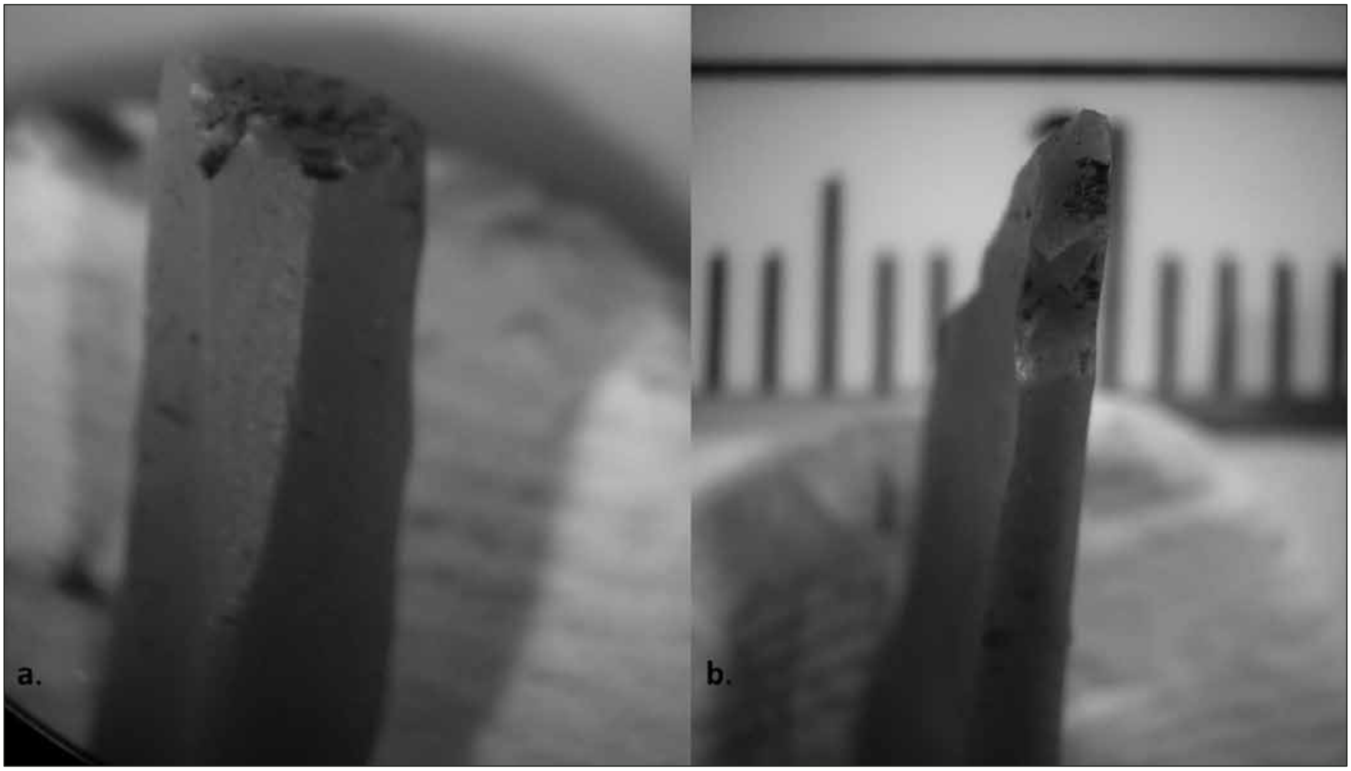

Figure 6. Two representative burin spalls exhibiting distal use-wear and retouch as seen under 10x magnification.

(Fig. 6a, b) and if there was damage to the dorsal and ventral sides. I recorded damage to the distal end of 77.1% (n = 54/70) of the spalls, but only 48.6% (n = 34/70) have definite use-wear. This means, by my estimation, 27.5% of the spalls have distal damage that should be attributed to spontaneous retouch.

Of the 70 recovered burin spalls from Matcharak Lake, 59 appeared unbroken. The average length of the 59 unbroken burin spalls is 15.5 mm, the average width is 3.52 mm, the average thickness 1.75 mm and the average weight is 0.13 grams. All of these values are statistically identical to the Iyatayet sample (Giddings 1964).

Giddings (1964) notes that 122 (55.7%) of the 219 spalls recovered from the Denbigh type-site, Iyatayet, exhibit use-wear on the distal end of the spall. Of the 70 burin spalls recovered from Matcharak Lake (AMR-186), 18 (25.7%) show definite retouch and 34 (48.6%) show evidence of use. An independent t-test of spalls with use-wear versus spalls with no use show there is a statistically significant difference between length and weight of spalls the Denbigh were selecting for use, although width and thickness are not significantly different (Table 1).

Eleven different raw materials were brought to Matcharak Lake and discarded as burin spalls (Table 2). Black and gray chert occur in the highest frequencies, making up 87.1% (n = 61/70) of the sample. This correlates well with the raw material represented by the burins themselves. Seven different raw materials represented by burin spalls indicate at least seven other burins passed through the site but were not recovered, meaning they are located in an unexcavated portion of the site or they were taken away as curated tools. Raw material type apparently played a minor role in how spalls were selected for use, as each raw material type has at least one representative spall with use-wear, except for the brown chert and obsidian, each represented by one spall. Attempted refits of spalls to the collected burins were unsuccessful, although two spalls did refit to each other.

To consider how the burin spall was used as a tool, I note that the dorsal side of the spall exhibits use 98.5% of the time. Use-wear is found on the ventral side only 10% of the time and generally this co-occurs with use-wear of the opposite side. When viewing the tip of the spall, distal end out, dorsal side up, the tip slants to the left 83.3% of the time for retouched burin spalls and 66% of the time for spalls exhibiting use-wear, a phenomenon noted by Giddings (1956:234), as well. This indicates the left corner of the distal end is preferentially used, by drawing the

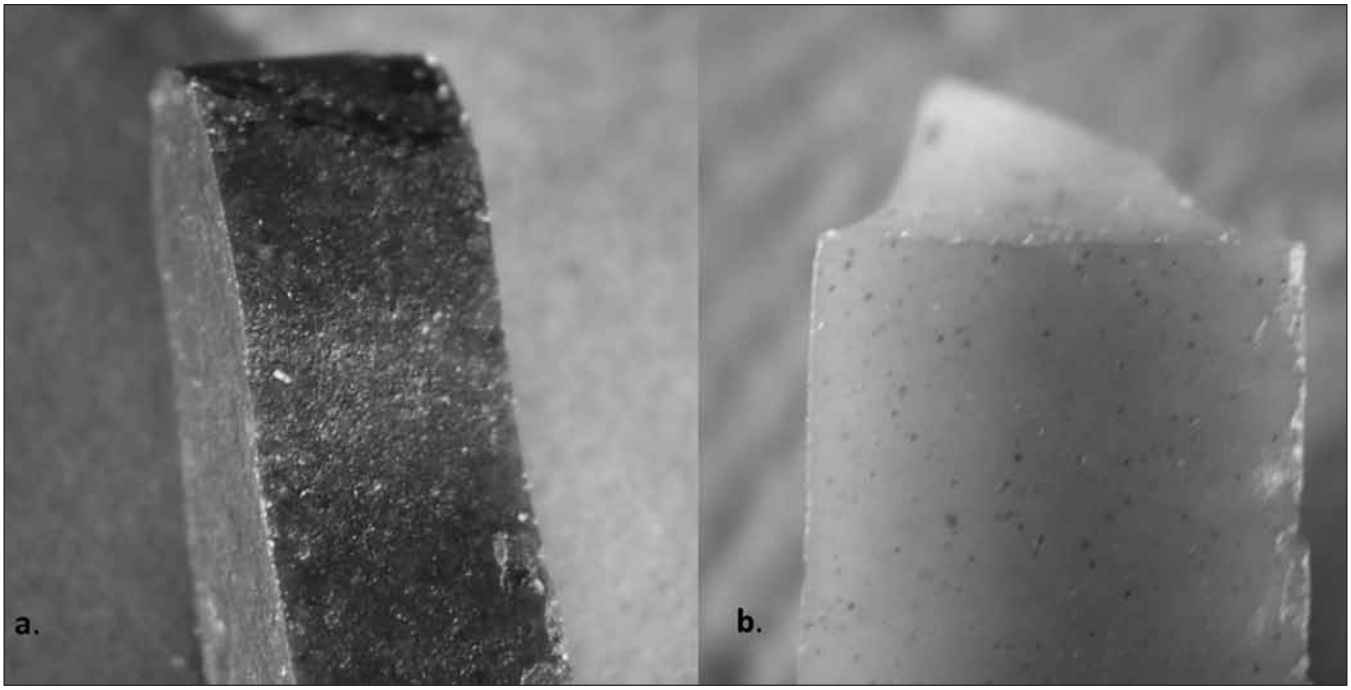

Figure 7. Two representative burin spalls exhibiting no retouch and natural breakage as seen under 10x magnification.

pointed corner towards the user. How the user held the tiny tool is uncertain, but there are implications for left- and right-handed spall users at Matcharak Lake (Giddings 1956:234).

Evidence for spall hafting is limited and ambiguous. Grønnow (1994:212) discovered a hafted microblade at Qeqertasussuk inset into a wood handle and lashed with baleen. Experimentation with a wooden haft left no identifiable wear patterns on my samples. Three of the 34 spalls that exhibit use-wear appear to have notches for hafting (see Fig. 5; fifth from left for an example). If the burin spall was hafted into a ball of mastic (Giddings 1964), I hypothesize one should see evidence of residue on the shaft of the spall. I recorded apparent residue on 27 of 70 spalls. Of these, 18 have retouch or use-wear present. However, of the 27 with residue, 9 lacked any evidence of use. If the residue is from hafting in mastic, all spalls exhibiting use-wear should have residue, so why do some exhibit residue with no evidence of use? Some spalls with use-wear may have been used expediently and were not hafted, or the residue might not have been preserved. Its presence on some spalls lacking use-wear might be because I have recovered only the proximal end of the spall. If the spall broke in half during use, the distal tip might be missing. Therefore, the presence of residue would indicate the spall was actually used. If the residue is a result of something in the soil adhering to it, it should be present on all of the artifacts. The fact that there is no residue on most spalls suggests that the residue is of cultural origin.

Not all of the burin spalls were used the same way. A small percentage (29.4%; n = 10/34) exhibit equal use

Table 1. Mean average length, width, thickness and weight for burin spalls exhibiting use-wear and no use-wear. An independent t-test ($p < 0.05$) with equal variances not assumed suggests there is a significant difference between the length and weight of the spalls chosen for use.

	Use-Wear	n	Mean	Std. Deviation	Std. Error Mean	Sig (2 tailed)
Length (mm)	Yes	34	15.872	5.053	0.867	p = 0.049
	No	36	13.577	4.494	0.749	
Width (mm)	Yes	34	3.595	0.667	0.114	p = 0.291
	No	36	3.415	0.747	0.125	
Thickness (mm)	Yes	34	1.705	0.440	0.075	p = 0.954
	No	36	1.711	0.437	0.073	
Weight (g)	Yes	34	0.142	0.079	0.014	p = 0.019
	No	36	0.102	0.058	0.010	

Table 2. Totals for burin spall raw material types divided by presence and absence of distal use-wear.

	Use-Wear		
Raw Material	No	Yes	Total
Basalt	1	1	2
Black Chert	17	11	28
Brown Chert	1	0	1
Clear Gray Chert	0	2	2
Dark Gray Chert	4	4	8
Gray Chert	12	11	23
Gray/Red Chert	0	1	1
Green Chert	0	2	2
Orange Chert	0	1	1
Striped Gray Chert	0	1	1
Obsidian	1	0	1
Total	36	34	70

across the distal tip. These burin spalls were used like tiny end scrapers (Giddings 1956:234), perhaps for fine scraping of small pieces of hide, for delicately shaping wood, or for shaving down pieces of antler and bone. While beyond the scope of this study, a further line of evidence concerning burin spall use could come from residue analysis, as some used spalls appear to have microscopic traces of some unidentified resin on their tips.

In summary, burin spall use was a common occurrence at Matcharak Lake. Burin spalls are the most common tool recovered here and nearly half exhibit use-wear on the distal tip, similar to Giddings' (1956) findings at Iyatayet. Spalls may be used for intricate design work or for scoring antler to be cut and shaped into tools. Giddings (1956:232) showed the burin to be an effective engraving tool on bone, but no experiments with spalls have shown them to be capable of incising materials as hard as bone or antler. The following experiment tests the burin spalls strength and durability for engraving tasks and links this to groove and cut marks on organic remains from AMR-186.

EXPERIMENTAL DATA

It is clear from this analysis and from the evaluation of numerous Denbigh Flint Complex sites in Alaska that burin spall use was a common phenomenon (Giddings 1964). How these tiny tools were being used has been a source of speculation (Giddings 1956). Giddings (1956:235–236) suggests:

> If we are not too far afield in considering the burin spall tools to have been hafted engravers, another reasonable guess is that the Denbigh Flint people gave free rein to their artistic talents, quite possibly in the field of the elaborate art styles that prevailed in the western Eskimo area some 2,000 years ago. Thus far, however, we have no organic materials from the oldest layer at Cape Denbigh, and therefore no proof of engraving skill.

With no organic tools found associated with the Denbigh Flint Complex, interpretation of burin and burin spall function was based on analogy and speculation. However, Matcharak Lake (AMR-186) provides researchers with new organic evidence that allows us to test some of the assumptions and proposed uses made by Giddings and others (Fig. 8). Worked bone and antler provide the first clear evidence that the Denbigh people used mitten-shaped burins or burin spalls as engravers (Fig. 8). How effective of an engraving tool is the burin spall?

To quantify the durability of the burin spall, I produced a small sample of burin spalls from gray, green and black chert, collected from cobbles at Akmalik Creek in Alaska's Brooks Range. One spall of white chert from the Hartville Uplift in Wyoming was used for comparative purposes. In total, thirteen spalls of various sizes and thicknesses were produced. I recorded the length, width, thickness and weights of each experimental spall. I then used the spall by holding it between my thumb and forefinger while drawing it back and forth across bone and antler to create an incised line. To quantify spall performance, I marked off five centimeter sections of a sample of caribou antler and on a slightly weathered section of caribou rib. I created one groove by pulling the spall towards me with one hundred strokes. For each experimental groove, I measured the width and depth of the groove produced and the length and weight of the spall after use. I also recorded whether the spall snapped during use prior to completing the allotted one hundred strokes.

Results of an independent means t-test suggest that length, width and weight had little to do with whether the burin spall broke during use, but a statistically significant difference between thicknesses of the spalls was responsible for the fracture during use ($p = 0.002$ at the 0.05 level of significance) (Table 3). Each chert type performed equally well. Each raw material type had at least one fracture. The white Hartville Uplift chert did fracture, but the spall was long enough to continue using it for 100 strokes. Only three burin spalls became unusable after fracture, and thus did not complete the 100 strokes. The average width and depth of the 5 cm groove for the spalls that did not fracture was 1.3 mm wide and 0.60 mm deep, while the grooves for fractured spalls averaged 0.86 mm wide and 0.33 mm deep. The measured width and depth of the three grooves from artistically decorated bone from Matcharak Lake (see Fig. 9) are: groove (1) 1.13 x 0.50 mm; groove 2) 0.97 x 0.71 mm; and groove 3) 0.65 x 0.54 mm. Another independent t-test shows that at the 0.05 level, there is no statistically significant difference between the sizes of my experimental grooves and the sizes of the decorated bone tool's grooves (p = 0.888 and p = 0.231).

For the burin spalls that did not break an average loss of 0.730 mm and 0.005 grams of material was recorded for production of a 50 mm long groove. This means that to produce a 500 mm long groove in bone or antler, approximately 7.3 mm of the spall would be lost. The grooves on the archaeological faunal piece are about 750 mm long. This suggests that (not taking into account sharpening) the grooves on the bone tool recovered from Matcharak Lake could have been produced by as few as two good sized burin spalls of high-quality raw material.

Other factors come into play that are more difficult to account for. For example, how does the hafting of a burin spall affect its performance? My makeshift expedient wood haft certainly made the spall easier to handle. Even after a half hour of use the spall was still able to remove small amounts of bone from the grooves, but the tip did get dull and polished. With increased use it eventually created a sharp edge on the other side, so that if I rotated the spall I was able to get a good bite again. Variable raw material and inherent flaws in the chert are factors in the spall's durability as an engraving tool. Dulling of the edge and the degree of retouch to sharpen the bit would all factor in the use-life of the burin spall, as would how hard the user presses down when using the tool. Perhaps less force but more strokes could increase the use life, but without a machine to measure force, this will remain somewhat subjective. The relative freshness of the bone or antler could also play a factor in burin spall use life. Both the bone and antler used in this study were recovered from animals that had been dead for at least one year. Soaking the antler in water would make it more pliable and easier to score, increasing the use life of the tool.

CONCLUSION

Analysis of the burin technology from Matcharak Lake shows that burin use went beyond the graver and core for spalls, as it appears the Denbigh treated their burins as multifunctional tools analogous to pocket knives (Tomaskova 2005). The burin technology of the Denbigh Flint Complex occupation at Matcharak Lake is stylistically identical to portions of assemblages at other Denbigh sites in Alaska; a few burin types recognized from Iyatayet were not recovered from Matcharak Lake. This may be due to the sample size or because of a shift to a simplified toolkit in the interior. The proposed function of burins as incising tools for insetting microblades is not conclusively supported by this analysis, because no organic points with inset stone were recovered. It seems likely that burins create a groove that is too thick for a microblade to fit snugly into but additional work needs to be done to confirm this. However, decorated bone, a groove on antler waste and one tiny incision on a bone point have established that engraving indeed was performed on organic tools made by the Denbigh, and burins and burin spalls were used to do this. It is clear from use-wear damage on the tip of the "mitten-shaped" burins that they were used as engravers. Occasionally, the faceted burin edge on the

Figure 8. Engraved decorated bone artifact recovered from Matcharak Lake (AMR-186)

Table 3. Mean length, width, thickness and weight of the experimental burin spalls grouped by whether or not they fractured upon use. An independent t-test ($p < 0.05$) suggests thickness is the only significant difference between those spalls that fractured and those that did not.

	Fracture	n	Mean	Std. Deviation	Std. Error Mean	Sig (2 tailed)
Length (mm)	Yes	6	20.392	6.209	2.535	
	No	7	17.544	2.883	1.090	p = 0.337
Width (mm)	Yes	6	4.005	1.022	0.417	
	No	7	4.657	0.993	0.375	p = 0.271
Thickness (mm)	Yes	6	1.892	0.521	0.213	
	No	7	3.073	0.550	0.208	p = 0.002
Weight (g)	Yes	6	0.208	0.168	0.068	
	No	7	0.287	0.100	0.038	p = 0.343

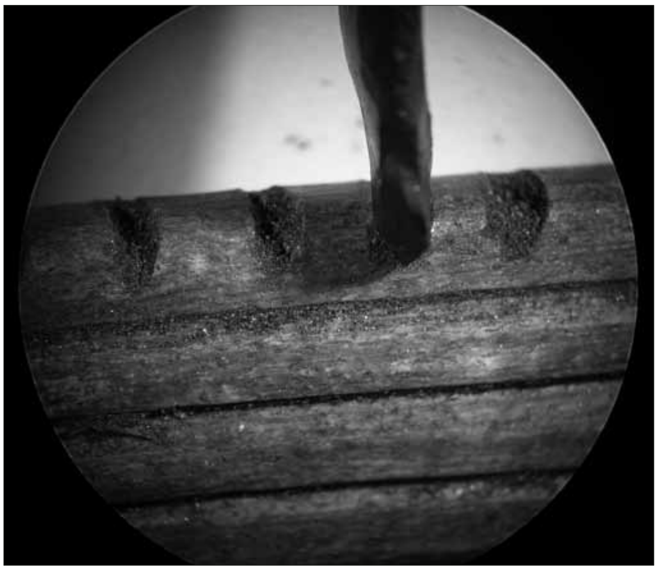

Figure 9. A magnified image of the engraved bone tool showing a correlation between notching widths and burin tip width.

Figure 10. Evidence of use-wear on the stem of the burin indicating use as a scraper; stained with red ochre.

stem was used as a scraper or whittling tool for working some fairly hard material. This burin edge was also rejuvenated by removing a spall that contained the dulled edge. Evidence for the burin being a hafted tool is recognized by edge grinding, slight notching and red ochre, which likely served as an adhesive. There is some evidence the burin blow technique was performed on end blades and scrapers for shaping a haft element. Burins also served as cores for producing spalls, which in turn were used as engraving tools. These four functions of the burin and burin blow technique are also recognized in Old World assemblages (Barton et al. 1996).

Burin spalls were a desired product which the Denbigh used as tiny engravers and scrapers. Use-wear on the distal ends indicates the larger spalls were often used, most likely in an expedient fashion. There is some microscopic residual evidence on the burin spall shafts that supports the hypothesis that spalls were hafted in a ball of mastic. ASTt people in the eastern Arctic had hafting techniques for microblades (Grønnow 1994:212). We should predict the same for ASTt groups in Alaska. My experimental results indicate burin spalls, if thick enough, are durable engraving tools capable of replicating the engraved artwork represented by the decorated bone from Matcharak Lake.

The people of the Arctic Small Tool tradition were obviously very conservative with their raw material. I am aware of no high-quality raw material sources near Matcharak Lake that could have provided their tool stone. No cores were recovered and most of the debitage is so small it was likely the result of pressure flaking. Future studies should compare burin spall use from sites with a local tool stone source versus ones farther afield. Furthermore, comparisons between different site types and from earlier or later occupations may show changes in the frequency of use for these tools.

AFTERWORD

Continued excavation at AMR-186 in 2009 led to the recovery of one additional "mitten-shaped" burin and four burin spalls which were not used in this study.

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