Beyond the Graver: Reconsidering Burin Function

C. Michael Barton
Arizona State University
Tempe, Arizona

Deborah I. Olszewski
Bishop Museum
Honolulu, Hawaii

Nancy R. Coinman
Iowa State University
Ames, Iowa

Burins have long been considered to represent a special class of stone tools, used primarily for engraving. A number of studies, however, have indicated that burins functioned in a variety of very different ways. This study finds evidence that burins were used as cutting/scraping tools, engraving tools, hafting elements, and bladelet cores at three late Pleistocene sites in SW *Asia. We suggest that burins should not be considered as a class of tools, but the varied products of a manufacturing technique analogous to retouch. Burination is simply a technique for removing mass from flakes and (more often) blades, serving to modify edges and produce spalls. This has important implications for the interpretation of lithic assemblages from the Upper Paleolithic through the Neolithic.*

Introduction

Since first noted by Lartet and Christy (cited in Movius 1968: 312) in the last century, burins have been considered a hallmark of Upper Paleolithic chipped stone assemblages. While they occur both prior to and after this period, they generally are seen as one of the more important tools associated with the morphologically modern humans of the last glacial episode. Given this association and the fact that many of our reconstructions of Upper Paleolithic hunter/gatherers are based on lithic artifacts, it is not surprising that the behavioral significance of burins has retained the interest of Paleolithic scholars for more than a century.

Lartet and Christy noted the regular occurrence of burins on the same pieces as other tools, such as endscrapers, and initially suggested that they might be a means of hafting artifacts (Movius 1968: 312). Shortly thereafter, a number of workers (e.g., Leguay 1877: 286–287) suggested that, rather than hafting elements, these lithic forms were functionally equivalent to small chisels or engraving tools. From this interpretation came the French term burin, or graver.

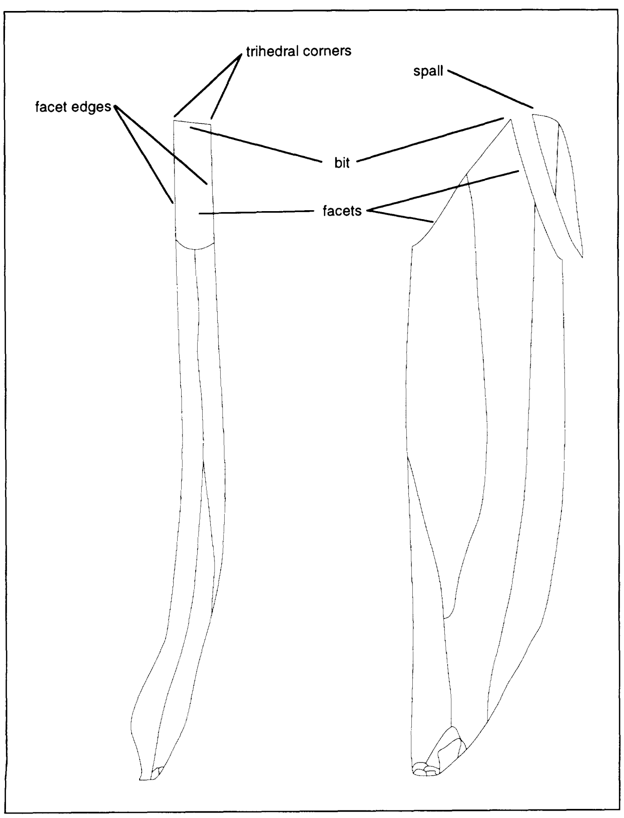
Since that time, burins have been recognized as a morphologically and functionally distinct set of stone artifacts. They generally have been considered to be tools for engraving or grooving relatively hard materials such as bone, antler, wood, ivory, or stone. Hence, burin typology and most studies of burins (morphological, functional, and/or stylistic) have focused primarily on the morphology of the burin bit, the chisel-like tip of the artifact (e.g., Dreiman 1979; Noone 1934; Sackett 1989). Conversely, a number of studies have challenged these long-held views and suggested other ways in which burins may have been used (e.g., Becker and Wendorf 1993; Büller 1983; Finlayson and Betts 1990; Knecht 1988; Moss 1983; Vaughan 1985). Alternative interpretations include the use of trihedral corners (see below) rather than the burin bit for engraving, the use of facet edges as cutting/scraping tools, and burins as bladelet cores; interestingly, some of these alternatives appear in the popular literature of the early 20th century (e.g., Begouën 1926: 138). The model we develop serves to integrate these apparently incongruous results and offers an explanation for the perceived functional diversity of burins. In so doing, we challenge the widely held concept of burins as a distinct tool class. The results are important for the role of burins in stone artifact systematics and for the interpretation of assemblages that contain them.

Burin Features

The fundamental characteristic that defines a burin is the removal of the edge (most often lateral or distal) of a flake or blade by means of one or more long, narrow flakes called *burin spalls* (FIG. 1). For a lateral edge, the spall is removed parallel to the long axis of the edge, and the spall width is equivalent to the thickness of the original piece. A distal removal parallels the transverse axis and also produces a burin spall with a width equal to original piece thickness.

Spall removal produces two morphological features common to all burins, the *burin facet* and the *burin bit* (FIG. 1). The burin facet is the scar resulting from removal of a burin spall; it usually exhibits a negative bulb of percussion. Depending on the number of spalls removed, a burin may have one or more facets. The number of facets and their location on a flake or blade is the primary determinant of burin classes in most typologies (e.g., Hours 1974; de Sonneville-Bordes and Perrot 1956; Tixier 1963, 1974).

Figure 1. Burin features discussed in text.

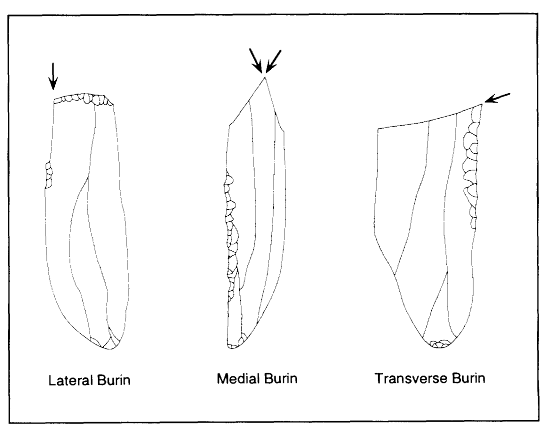


The burin bit is the sharp, usually chisel-like edge, formed by the intersection of a facet and the surface that served as a platform for spall removal. This surface can be unmodified or formed by a break (usually transverse), retouch (a truncation or retouched lateral edge), or another burin facet. The morphology and location of the spall removal surface usually forms the secondary determinant of burin classes (e.g., Hours 1974; de Sonneville-Bordes and Perrot 1956; Tixier 1963, 1974).

Several sharp, potentially usable edges or points also are characteristic of all burins. *Facet edges* are steep, regular, sharp edges formed by the intersection of a burin facet and the interior or exterior face of the original piece. *Trihedral corners* are formed by the intersection of a facet, spall platform surface, and the exterior or interior face of the original piece (FIG. 1).

Although burins have been classified in many ways, most fall into three general morphological categories, here termed medial, lateral, and transverse burins. Medial burins are formed by two or more facets, along opposite lateral edges of a piece, that intersect at the distal (or more rarely proximal) end of a piece (FIG. 2). Dihedral burins are the best known examples of this category. Lateral burins have a facet along one lateral edge of a piece that intersects a spall removal surface on the distal end of the piece (FIG. 2). This spall removal surface can be a retouched truncation, transverse break, another burin spall, or the unmodified distal end. Angle burins on breaks or truncations are common representatives of this category. The third category, transverse burins, includes burins with one or more spalls that extend transversely across the distal (or more rarely, proximal) end of a piece (FIG. 2). The spall removal surface may be an area of lateral retouch, a break, or an unmodified lateral edge.

Figure 2. General classes of burins. Lateral includes angle burins, and medial includes dihedral burins.



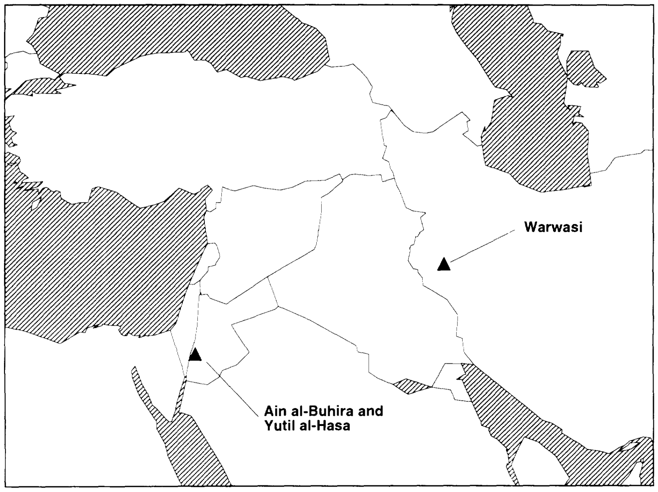


Figure 3. Sites discussed in text. Sources of burins analyzed.

Table 1. Artifact and burin counts from each site.

Site (assemblage)	*Burins studied*	*Total lithics*
Warwasi (Baradostian)	295	11,315
Warwasi (Zarzian)	40	17,083
Ain al-Buhira	108	36,393
Yutil al-Hasa	22	5,224

Samples Used in this Study

The burins from three late Pleistocene sites in SW Asia (FIG. 3) were examined to study the potential range of uses of these ubiquitous artifacts. The sites are Warwasi Rockshelter in Iran, and Ain al-Buhira (WHS 618) and Yutil al-Hasa (WHS 784) in Jordan. Burin and overall artifact counts from each site are shown in Table 1. Warwasi is a deeply-stratified shelter site, situated high above a valley floor in the foothills of the Zagros Mountains. It was occupied during the Middle Paleolithic, the early and late Upper Paleolithic, and the Epipaleolithic. The site was tested in 1960 by Bruce Howe, under the direction of Robert Braidwood, during the Iranian Prehistory Project (Braidwood, Howe, and Reed 1961), and detailed analysis of the lithic assemblages recently was completed by Harold Dibble and Deborah Olszewski (Dibble and Holdaway 1990, 1993; Olszewski 1993a, 1993b; Olszewski and Dibble 1994).

The burins selected for this study are from the late Upper Paleolithic (late Baradostian) levels P-Z, and the Epipaleolithic (Zarzian) levels A-O. Although Warwasi has not been directly dated, the similarities between the materials from Levels A-Z and those of dated Zagros sites, such as Shanidar Cave Layer C (Solecki 1958) and sites in the Khorramabad (Hole and Flannery 1967), suggest that the late Baradostian at Warwasi falls between 30,000 and 20,000 B.P., while the Zarzian levels were deposited sometime between 20,000 and 10,000 B.P.

Ain al-Buhira and Yutil al-Hasa are both situated in the eastern Wadi al-Hasa in west-central Jordan. They were located in Burton McDonald's survey of the southern bank of the Wadi al-Hasa in 1982 (MacDonald 1988; MacDonald et al. 1983), and were tested during the 1984 Wadi al-Hasa Paleolithic Project, directed by Geoffrey Clark (Clark et al. 1987, 1988). The lithic assemblages have undergone extensive analyses since then (Coinman 1990, in press; Olszewski, Clark, and Fish 1990).

Ain al-Buhira (WHS 618) is a large, open site situated along the SW margins of the former Pleistocene Lake Hasa, now a dessicated plain. The archaeological stratigraphy of the site is complex. At least two stratigraphically and spatially separated occupations have been identified (Coinman 1990, in press; Schuldenrein and Clark 1994). A late Ahmarian occupation, dated at 20,300 ± 600 B.P. (UA-4395), is associated with the spring and the tufa formations in the southern portion of the site; earlier occupation episodes appear to have occurred across the main area of the site between ca. 25,000 and 20,000 B.P. The density, composition, and diversity of the lithic material recovered from Ainal-Buhira attest to the long-term importance of this spring and lakeshore site. The locality most likely served as a base camp, although the actual duration of individual encampments is as yet unknown.

Yutil al-Hasa is a relatively small rockshelter located about 3 km north of Ain al-Buhira. A radiocarbon sample from a hearth in the upper levels of Unit A yielded a date of 19,000 ± 1300 B.P. (UA-4396). The lithic assemblage from Test Units A and B most closely resembles that of the Ahmarian Upper Paleolithic tradition (Olszewski, Clark, and Fish 1990). Close to freshwater springs, it is probable that Yutil al-Hasa functioned as a task-specific site, where game migrating through the Hasa drainage system could be monitored and taken (Clark et al. in press).

Methodology

As previously discussed, most archaeologists consider burins to have been primarily engraving tools. Alternative functions have been proposed, however, on the basis of studies of microwear and burin morphology. Our primary objective here is to evaluate alternative hypotheses for burin function, using assemblages from the three sites described above. Specifically, we focus on four proposed burin functions: 1) as engraving tools; 2) as general purpose cutting/scraping tools; 3) as bladelet cores; 4) as tangs to haft artifacts. To assess these possibilities, we use a

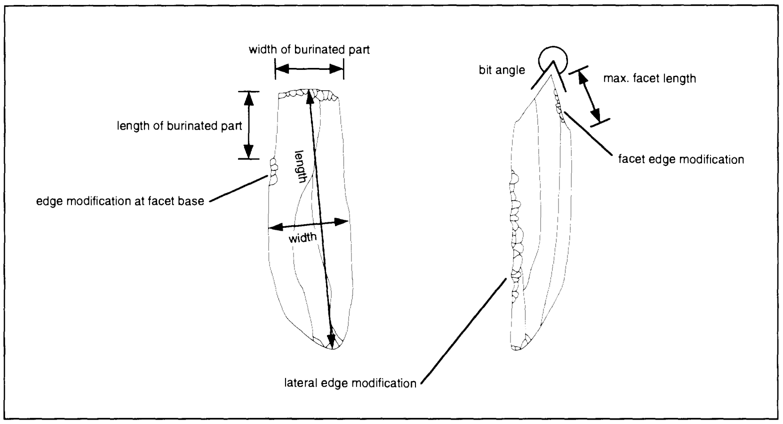


Figure 4. Selected measurements on burins.

broad-based approach that includes burin morphology, macroscopic evidence of edge modification (from use or retouch), burin use-life patterns, and covariance with other artifacts.

We quantified the characteristic morphological features of burins for analysis, including the size of the burinated area (length and width), the bit angle, the maximum facet length, and the number of major facets on either side of the bit. We noted whether the end opposite the burinated portion was complete or broken, and plain or modified. If this opposite end was another burin, it was measured in the same way as the primary burin. If the opposite end exhibited another form of modification, it was classified in a standard typology.

Macroscopic evidence of edge damage or retouch was recorded for burin bits and facet edges to indicate the locations of most intensive use. Similar information on the use of the rest of the artifact also was collected, including presence of edge modification at the base, or distal end, of burin facets and along non-burinated edges.

We gathered additional information on the manufacturing technology and form of the blank on which each burin was made. Measurements on entire artifacts provided control data and included size, amount of cortex, and blank type. Specific measurements are shown in Figure 4 and listed in Table 2.

All burinated ends were classified using a standard Upper Paleolithic and Epipaleolithic typology. Widely used typologies usually are the product of long experience and an intuitive appreciation on the part of the typologist for the range of variability present. As such, typologies sometimes can serve as summary measures of quantitative variability in artifacts. We felt that a more detailed typological scheme, in which classes could be recombined as necessary to represent functionally homologous groups, would be more useful in this way than a typology with few burin classes. We chose one of the most detailed classification systems for burins that is not based on attribute analysis, that of Francis Hours (1974: 12–14).

Results

One of the more notable initial findings of this study is the largely continuous distribution of variability in the morphology of features that define burins (FIGS. 5–6), even though the range of variability is large. These results parallel other recent, quantitative analyses of prehistoric chipped stone artifacts (e.g., Barton 1991; Coinman 1990; Dibble 1987, 1991; Rolland and Dibble 1990; Flenniken and Wilke 1989; Neeley and Barton 1994; Olszewski 1993c; Toth 1985), and suggest that many of the burin types recognized by archaeologists do not represent distinct tools whose forms were planned by prehistoric artisans. Rather, many typological distinctions result from technical aspects of manufacture and the effects of use and maintenance. As discussed below, however, burins also display considerable functional diversity (more so than most other classes of chipped stone artifacts) that crosscuts traditional burin systematics.

Burins as Engraving Tools

As previously noted, burins have been considered tools for grooving and engraving—with the bit the utilized part of the burin—since the late 19th century (eg., Bordes 1967; Dreiman 1979; Keeley 1982; Moss 1978; Seitzer 1978; Semenov 1964; Stafford 1977). We, too, found evidence that could support the use of burin bits in the assemblages examined for this report.

Bit end modification, in the form of flake scarring and fracturing, occurs on the majority of burins from the Warwasi Zarzian (69% of burins), Ain al-Buhira (83%), and

Table 2. Measurements on artifacts.

Variable	*Measurement scale or possible values*
Whole Piece	
Site name or number	–
ID#	–
Provenience	–
Type	F. Hours (1974) typology
Length	mm
Width	mm
Thickness	mm
Amount of cortex	<10%, 10–90%, >90%
Blank type	1° prismatic, 2° prismatic, non-prismatic, core tablet, core rejuvination flake, core/core tool, other
Condition	complete, broken, fragment/shatter
End 1 (Burinated)	
Location on blank	proximal, distal, lateral, unknown
Type	F. Hours (1974) typology
Condition of end	complete, broken, unknown
Length of burinated area	mm
Maximum width of burinated area	mm
Bit angle	degrees
Maximum facet length	mm
Number of facets >5 mm long	count for side 1, count for side 2
Burin bit modification	heavy, fine regular, fine irregular, plain
Facet edge modification	heavy, fine regular, fine irregular, plain
Facet base modification	heavy, fine regular, fine irregular, plain
End 2 (Burinated or Retouched)	
Location on blank	proximal, distal, lateral, unknown
Type	F. Hours (1974) typology
Condition of end	complete, broken, unknown
Length of burinated area	mm
Maximum width of burinated area	mm
Bit angle	degrees
Maximum facet length	mm
Number of facets >5 mm long	count for side 1, count for side 2
Burin bit modification	heavy, fine regular, fine irregular, plain
Facet edge modification	heavy, fine regular, fine irregular, plain
Facet base modification	heavy, fine regular, fine irregular, plain
Non-Burinated Lateral Margins	
Right edge	heavy, fine regular, fine irregular, plain
Left edge	heavy, fine regular, fine irregular, plain
Remarks/drawing	additional remarks and/or sketch if useful

Yutil al-Hasa (64%). Bit end modification is present on only 21% of burins from the Warwasi Baradostian, however. In fact, the modification exhibited by nearly half of the burin bits from the Wadi al-Hasa sites (45% at Ain al-Buhira and 41% at Yutil al-Hasa) falls into the "heavy" (i.e., most intensive) category. This evidence of modification is not inconsistent with that expected if the bits were used for tasks such as grooving and engraving.

We also discovered, however, in experimental work to establish baselines for assessing edge modification/damage, that damage from the process of burination (i.e., spall removal) mimics that from bit use at a macroscopic scale. Even in situations where burins are grooving/engraving tools (as may, indeed, be the case for many of these artifacts from the Wadi al-Hasa sites) the potential for this type of manufacturing damage complicates assessment of the extent of burin tip use in archaeological assemblages. Indeed, the situation is even more complicated, and there is additional evidence that these burins were used in a variety of different ways.

Burins as Multipurpose Cutting/Scraping Tools

A number of workers have proposed that burins functioned as general-purpose cutting/scraping tools (Bordes 1965; Callow 1986; Crabtree and Davis 1968; Knecht 1988; Moss 1983: 154), noting that removal of a burin spall creates a straight, sharp, durable edge along both lateral margins of a burin facet. Similarly, burination could be used to rejuvenate a use-worn or retouched edge (Vaughan 1985). We found evidence to support such use of burins among the assemblages studied. At Warwasi, facet edge modification was found on 11% of the burins

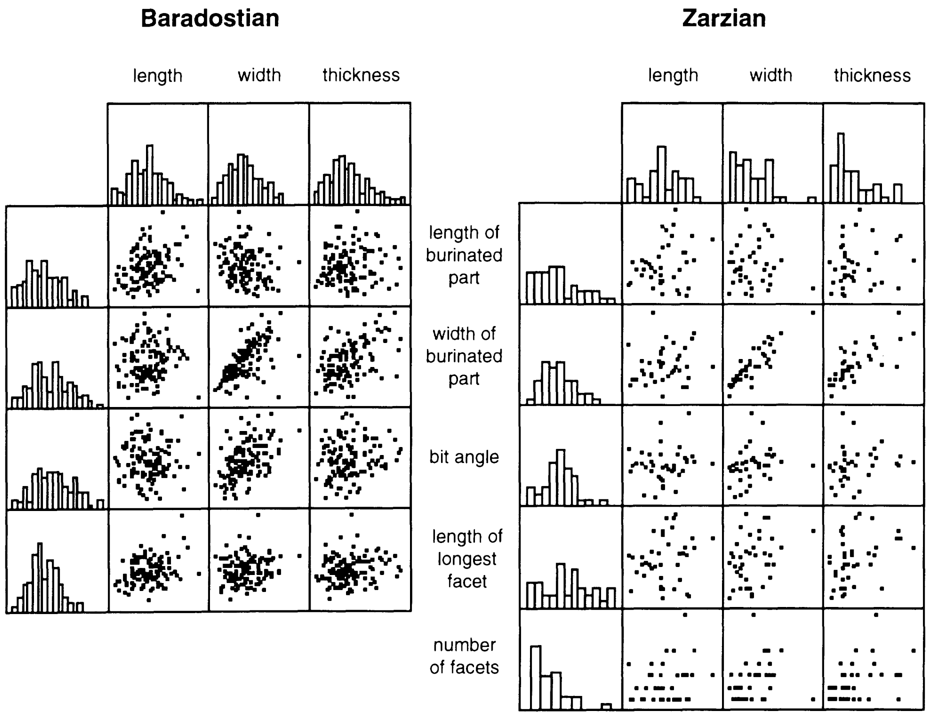


Figure 5. Distributions of morphological features on burins from Warwasi, by assemblage.

Figure 6. Distributions of morphological features on burins from from Wadi al-Hasa sites.

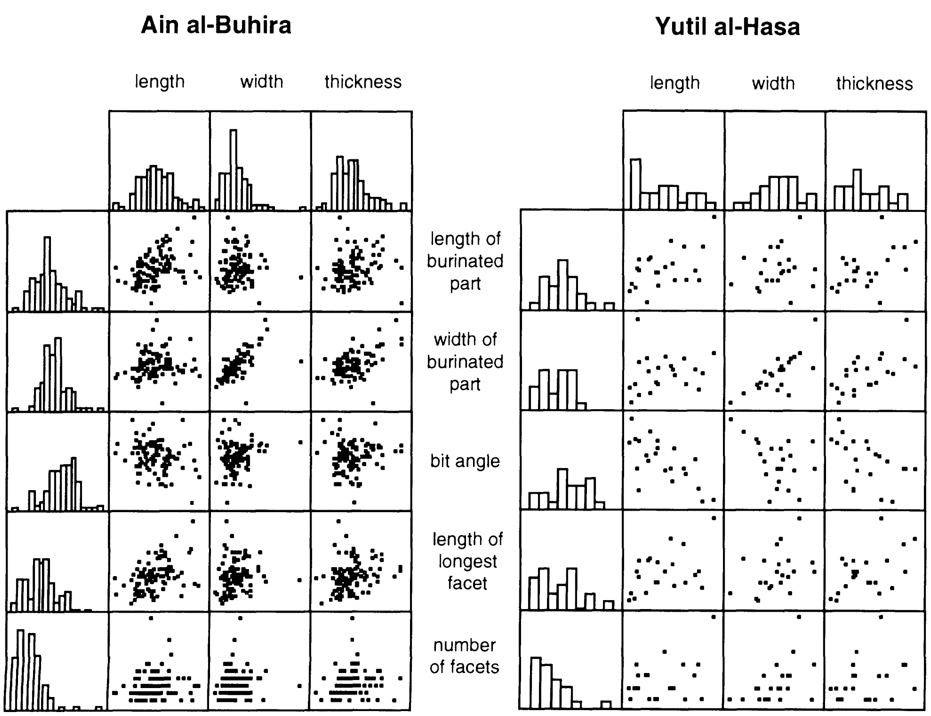


Table 3. Spearman rank order correlations (r) for intensity of modification of facet edges and bits, and facet edges and non-burinated lateral margins.

Site/Phase	*Facet edges and bits*	*Facet edges and lateral margins*	*Cases*
Warwasi Baradostian	−0.051	0.249*	292
Warwasi Zarzian	−0.058	0.300*	40
Ain al-Buhira	−0.152	0.182	96
Yutil al-Hasa	0.057	0.201	22

* Indicates significant correlation at $\alpha = 0.05$.

from the Baradostian and 23% of burins from the Zarzian. At the Wadi al-Hasa sites, evidence for facet edge use was even more prevalent, occurring on 41% of the burins from Ain al-Buhira and 27% from Yutil al-Hasa.

A feature commonly noted among burins in all assemblages studied is a small amount of retouch at the base (i.e., farthest from the bit) of the burin facet. This facet base retouch was found in 29% of the burins from the Baradostian assemblages at Warwasi, 46% of the Zarzian Warwasi burins, 54% of the burins from Ain al-Buhira, and 61% of the Yutil al-Hasa burins. If burination served to resharpen worn or retouched edges, remnant retouch might be expected to occur at this locality. Alternatively, such retouch may have served to control the length of a burin spall during edge creation or maintenance (but also see below). In either case, the presence of macroscopic damage on facet edges in conjunction with the common occurrence of facet-base retouch suggests that burin facets may well have served as general-purpose cutting/scraping edges.

Modification of facet edges seems to be weakly associated with modification of non-burinated lateral margins, but not with bit modification. A Spearman rank order correlation matrix for intensity of modification of facet edges, lateral margins, and bits (TABLE 3) shows weak positive correlations for modification on facet edges and lateral margins. Only two of these correlations (both from Warwasi, interestingly) are significant at $\alpha = 0.05$, however. This association lends additional, though far from conclusive, support for facet edge use among the burins studied. The lack of correlation between facet edge and bit modification indicates that facet edge modification does not predominantly occur on burins either with or without bit modification.

Burins as Cores

Studies of burins usually have focused on the burins themselves and ignored the spalls produced (however, see Becker and Wendorf 1993; Finlayson and Betts 1990; Gaussen and Gaussen 1965; Giddings 1956; Massaud 1972; Noone 1950: 190; Olszewski 1993a; Tixier 1963: 80). Burin spalls are often equivalent in size to the bladelets commonly found in Upper Paleolithic and Epipaleolithic assemblages that also produce burins. One class found in such assemblages, polyhedral burins (i.e., multi-facetted burins, broadly including "carinated" and "busked" burins), also superficially resembles bladelet cores. Polyhedral burins are more common at Warwasi than in the Wadi al-Hasa assemblages (11% of Baradostian burins and 17% of Zarzian burins, but only 4% of burins from Ain al-Buhira and lacking in the Yutil al-Hasa assemblage). In fact, the greater number of facets is one of the more notable morphological characteristics that distinguishes Warwasi burins, especially those of the Baradostian levels, from those of the Jordanian sites. Some 63% of the Baradostian burins have more than four facets on the primary burin end, whereas only 17% of the Zarzian burins at Warwasi, 14% of the Ain al-Buhira burins, and 9% of the Yutil al-Hasa burins have more than four facets. This suggests that some burins, especially in the Baradostian assemblages at Warwasi, served as bladelet cores (also see Olszewski 1993a).

Comparing the morphology of Baradostian burins and cores from Warwasi lends support to this hypothesis. A series of measurements were taken on cores from the Upper Paleolithic Baradostian levels (P-Z) for comparison with burins. Baradostian burins, and especially polyhedral burins, are morphologically similar to cores. Specifically, burin-bit angles fall within the range of exterior platform angles on cores, the count of burin facets is within the range of bladelet-removal scars for cores, and the lengths of the longest burin facets fall within the range of values for longest bladelet removal scars on cores (FIGS. 7–9). Additionally, the Baradostian burins at Warwasi show little evidence of use. As previously noted, both bit modification (at 21% of burins) and facet edge modification (at 11%) are notably less frequent in the Baradostian assemblages than in the other assemblages.

In addition to morphological evidence, the frequencies of burins and cores covary over time at Warwasi, and both burins and cores covary with debitage frequencies. They do not covary with the frequencies of other retouched

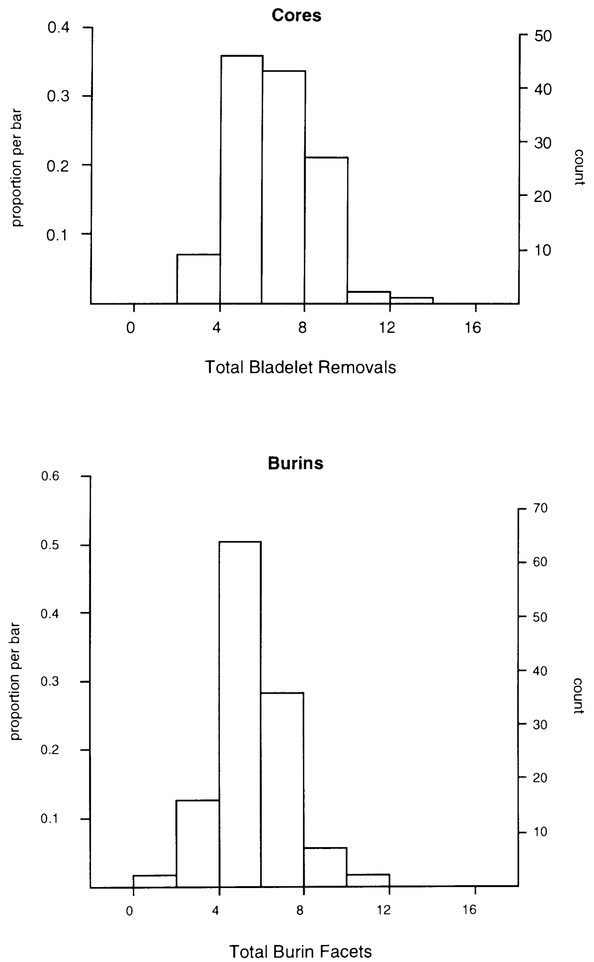


Figure 7. Comparison of the number of bladelet removals from cores and the number of burin facets for the Warwasi Baradostian.

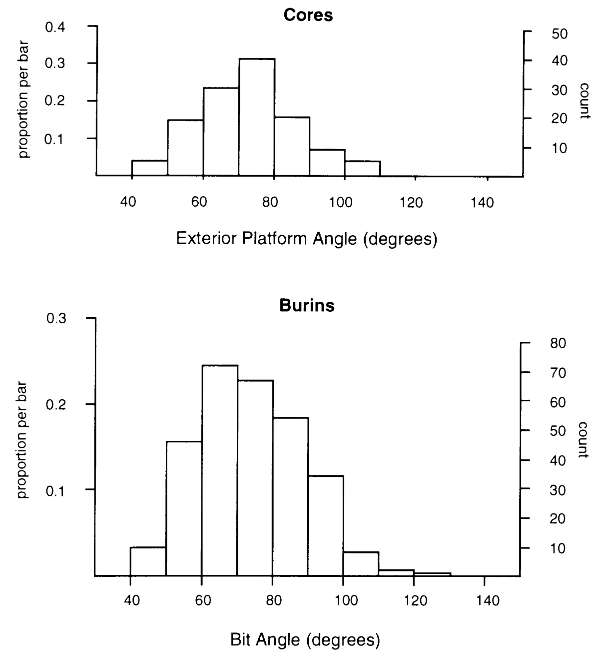


Figure 8. Comparison of core exterior platform angle and burin bit angle from the Warwasi Baradostian.

pieces or with microliths, however, which covary highly with each other (TABLE 4).

On the one hand, the frequencies of discarded cores and debitage relate to flake and bladelet manufacture, and to the expedient use and discard of unmodified flakes. Retouched tool and microlith frequencies, on the other hand, result from maintenance of compound/hafted tools (e.g., microlithic tools and endscrapers), and the discard of heavily used and/or curated tools (e.g., sidescrapers). The covarience of burins with the former group of artifacts, rather than the latter, supports an association with core reduction and lithic artifact production, rather than tool use.

Another potential way in which to examine the use of burins as cores would be to look for burin spalls among the bladelets and microlithic tools. For the collections we examined, however, the morphology of the exterior face of burins used in this way is often indistinguishable from other bladelet cores. Hence, it would be very difficult (if indeed possible) to differentiate spalls produced from such "burin cores" from other bladelets.

As previously noted, polyhedral burins also are present at Ain al-Buhira and Yutil al-Hasa, but in considerably lower frequencies than at Warwasi. Nevertheless, they also may have served as cores at the Jordanian sites. This difference may be due, at least in part, to variability in raw material availability between the two regions. The scarcity and small size of flint at Warwasi (and the Zagros region in general) may have encouraged the use of flakes and blades as bladelet cores, in addition to cores from nodules, to make more efficient use of raw material. On the other hand, flint is much more easily available in the Wadi al Hasa, making such economizing measures unnecessary.

Burins as Hafting Elements

One of the earliest hypotheses about the function of burins was that they served as hafting elements, or tangs, for tools such as endscrapers, perforators, and unretouched blades (Lartet and Christy, cited in Movius 1968: 312). In fact, the appearance of burins on pieces with sufficient retouch to be classed as formal tools is a common enough occurrence that categories for such "multiple tools" are found in most Upper Paleolithic and Epipaleolithic typologies (e.g., Hours 1974; de Sonneville-Bordes and Perrot 1956; Tixier 1963, 1974).

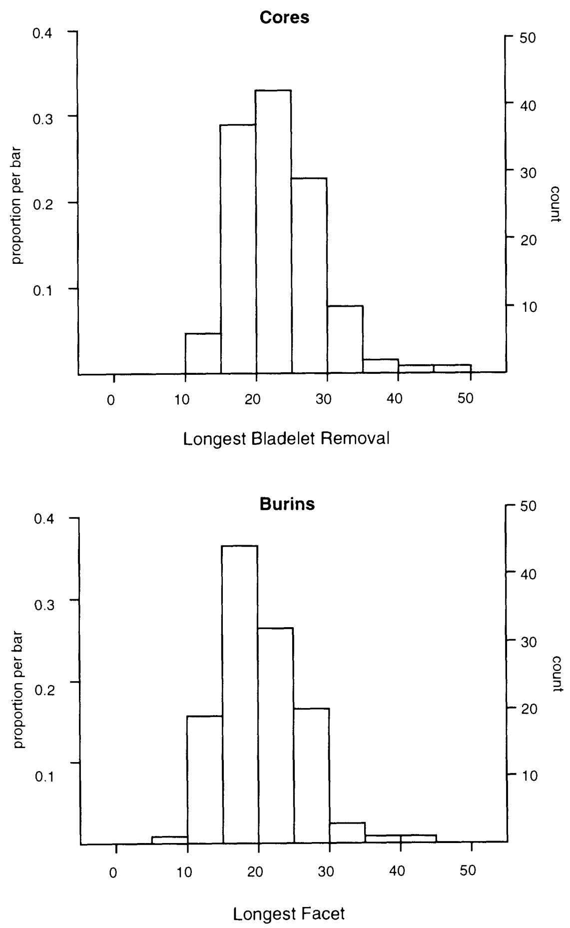


Figure 9. Comparison of the longest bladelet removal scar from cores and longest burin facet for the Warwasi Baradostian.

The end of a blade can be modified by burination to allow it to be inserted into a socketed or slotted haft (Büller 1983: 109–110; Keeley 1982: 801; Mortensen 1970; Semenov 1964). Most important to producing a serviceable "tang" would be the alteration of width, so that a blade could fit into a pre-cut socket or slot. Morphologically, the spalled portion would need to be rather narrow, and long enough to hold the lithic tool relatively rigid in the haft during use. Certain burin forms, primarily medial and lateral burins, provide these characteristics, while others, such as transverse burins, seem less useful for hafting. An additional requirement concerns the need for control over the length of spall removal along the blade edge so that the potential working edge is not overly shortened. This could be accomplished by making a small notch on the lateral margin of a blade to terminate the spall fracture.

Hafting use-wear can be difficult to identify (Becker and Wendorf 1993; Keeley 1982: 807) and, in the case of burins, might vary considerably. Potential use wear could range from minimal polishes from wood, bone, mastic, or animal tissue wrapping along the facet edges, to intermittent fine flaking along facet edges, to significant damage to both facet edges and bits as tool use stressed tang margins against hard handle material such as antler or bone. In fact, such wear does occur occasionally on burins (Knecht 1988; Vaughan 1985). Other evidence, however, appears to more consistently provide information about the use of burins as hafting elements.

If burins served as tangs, their use life should be similar to that of other hafted processing tools, with respect to patterns of use and discard. Of Upper Paleolithic and Epipaleolithic tools at the sites studied, endscrapers are likely to have been most consistently hafted. Detailed information on endscrapers is available for the Wadi al-Hasa sites (Coinman 1990), and use life patterns of burins can be compared with those of endscrapers.

Stone tools are discarded when they break or are worn out, and rejuvenation is not considered worth the effort. In hafted tools, a common location of breakage would be at or near the distal end of the haft because of the haft's resistance to tool flexion during use. An assemblage of discarded endscrapers would include unbroken, exhausted

Table 4. Matrices of Spearman correlation coeficients for artifact frequencies at Warwasi. All correlations are significant at $\alpha = 0.05$. In each matrix $n = 25$.

	Burins	*Cores*	*Non-microlith tools**	*Microlith tools*
Burins	1.000			
Cores	0.702	1.000		
Non-microlith tools	−0.682	−0.719	1.000	
Microlith tools	−0.692	−0.721	0.874	1.000

	Burins	*Cores*	*Debitage*
Burins	1.000		
Cores	0.702	1.000	
Debitage	0.718	0.705	1.000

* Excluding burins.

Table 5. Breakage frequency for burins with tools and endscrapers. (Only burins with a tool or break on the opposite end are used to compute breakage frequency. See text.)

	Burins		*Endscrapers*	
Site	*breakage (%)*	*n*	*breakage (%)*	*n*
Combined Wadi al-Hasa sites	40	48	40	361
Warwasi Zarzian	41	22	63	26
Warwasi Baradostian	15	63	54	33

endscrapers and the unhafted working end of broken endscrapers. (The hafted part of a broken endscraper is unlikely to be recognized as such; it may be a "burin," for example). On the other hand a potential discard assemblage of burin-tanged tools would include unbroken burins with tools on the opposite end (i.e., "multiple tools") and broken burins, representing the hafted portion of such tools. The frequency of breakage can be computed for endscrapers and possible burin-tanged tools to compare use life patterns (TABLE 5). As can be seen, there is close correspondence between breakage ratios for burins and endscrapers in the Wadi al-Hasa assemblages. Interestingly, the breakage ratio for Zarzian burins from Warwasi is close to the value for the Wadi al-Hasa sites though somewhat lower than the ratio for endscrapers. This could indicate the mixed functional nature of the burin assemblage, some examples of which may have served as cores. The breakage ratio for Baradostian burins, many of which may have served as bladelet cores, is much lower than the ratio for endscrapers.

As mentioned above, medial and lateral burins are more likely than are transverse burins to have served as hafting elements. Possible evidence of such use as tangs includes the presence of significant modification on the end opposite the burin and breakage. As indicated in Table 6, modification classifiable as formal tools and breakage is more common on medial and lateral burins than on transverse burins in all assemblages studied. This difference is most pronounced for burins from the Wadi al-Hasa sites and from the Warwasi Zarzian assemblage, but is also apparent in the Warwasi Baradostian assemblage. As noted above, the length of spalling for medial and lateral burins could be controlled by retouching a notch at the point where spalling should stop. This could be as effective for controlling tang length as for controlling facet length for other purposes. This retouch is much more common on Wadi al-Hasa and Zarzian Warwasi burins than on Baradostian Warwasi burins (see above).

Finally, the lengths of broken burins should approximate socket or slot depth for hafts in a given assemblage. As such they should be more or less equivalent to the lengths of the burinated portion of other burin tangs (i.e., burins with tools on the opposite ends) and to the tang lengths of other spent, hafted tools, such as endscrapers. As shown in Figure 10, this tends to be the case.

Discussion

Evidence has been presented in support of several alternative hypotheses for the functional significance of burins, but no single suggested function appears to be the primary use for these artifacts. One could conclude from this that burins, like many lithic artifacts, were multi-functional tools. The diversity of functions discussed above—engraving tools, general purpose cutting/scraping tools, cores, and tangs—encompasses nearly the entire range of functions for lithic artifacts, however.

Given this extraordinary functional range, it is important to remember that the fundamental morphological criterion for classifying a chipped stone artifact as a burin is simply the removal of a burin spall from the edge of a blade or flake. That is to say, a burin is defined only by the way in which mass is removed from the edge of a blade or flake.

Figure 10. Comparison of burins and endscrapers from the Wadi al-Hasa sites. Notches on box plots indicates 95% confidence intervals around the medians.

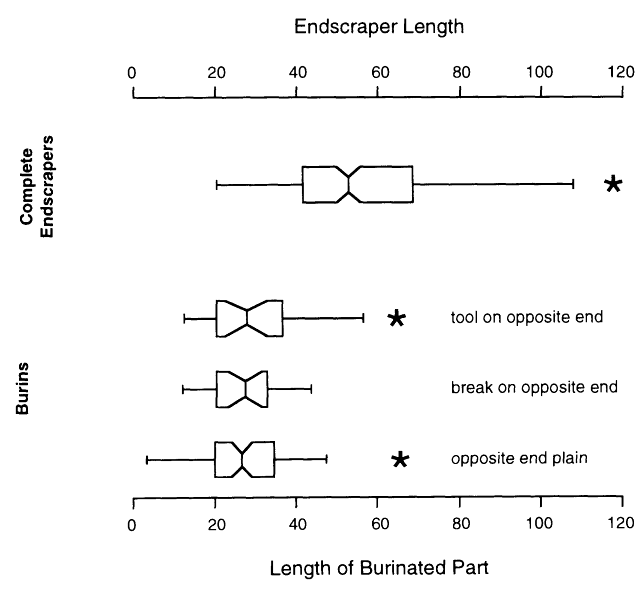


Table 6. Modification and breakage on medial/lateral and transverse burins.

	Tool or break		*Plain*		
Site and burin class	*n*	*%*	*n*	*%*	*Total*
Ain al-Buhira					
medial/lateral	36	36	65	64	101
transverse	2	29	5	71	7
other	2	40	3	60	5
Yutil al-Hasa					
medial/lateral	8	44	10	56	18
transverse	0	0	4	100	4
Zarzian					
medial/lateral	19	53	17	47	36
transverse	3	25	9	75	12
Baradostian					
medial/lateral	57	22	198	78	255
transverse	6	15	34	85	40

Expanding on Noone's (1934: 91) observation that the diversity of the forms included in the typological class of burins leads to a fuzzy boundary with other tool classes, and on Gidding's (1964: 211) comment that the use of the term burin does not necessarily imply similar function, we suggest that this technique for edge mass removal has little to do with the use to which the blade, flake, or spall was ultimately put. That is, burination, like retouch, served simply as a technique for edge reduction and modification. Both burination and retouch can produce pointed engraving tools. Both techniques can produce general-purpose cutting/scraping tools. Both can be employed to fashion hafting elements for tools.

Given the evidence presented above, we question the widespread assumption that burins are primarily a class of engraving tools for working other materials. Furthermore, archaeologists should reconsider the inclusion of burins in lithic typologies at the same analytical level as such artifacts as endscrapers, perforators, sidescrapers, and notches. Whether intentionally shaped or the end-product of a use/rejuvenation process, these latter artifacts are all retouch-modified, and the classes reflect some degree of specificity in function or amount of use. Burinated "tools" could be subdivided in the same way—a "burin graver," "burin scraper," or "burin core," for example. Burins as a group, however, should be considered systematically equivalent to retouched tools as a group rather than to a particular subclass of retouched tools. In fact, burin tools might be better classed with their retouched counterparts in cases where function is an important analytical goal, although this presents problems in identifying function on the basis of macromorphology (see below)—problems shared by retouched tools (e.g., Barton 1991).

Redefining burination as a reduction technique rather than a tool class raises the question of its high frequency in the Upper Paleolithic. Burination appears sporadically from the Lower Paleolithic onwards, but only becomes significant with the beginning of the Upper Paleolithic. This has been interpreted to signal the diversification of Upper Paleolithic tool kits by increased working of bone, antler, and wood, and has been linked to increased mental or symbolic capabilities of modern *Homo sapiens* (e.g., Aiello 1993: 83; Clark 1983: 7–8; Klein 1989: 311; Trinkaus 1986: 202). This explanation is no longer tenable if burination is simply a technique of edge reduction. Nevertheless, the increase in burin frequency in some Upper Paleolithic assemblages is real. We suggest that this pattern can be explained by examining the circumstances in which burination can serve as a viable, or even desirable, alternative to retouch for edge reduction.

Spall fractures initiated on convex-edged flakes will tend to exit the edge soon after initiation, producing short spalls and modifying only short edge segments. On the longer, straighter edges of prismatic blades (and Levallois points) spall fractures can travel a greater distance. Consequently, burination can modify a much longer length of a blade edge than of a flake edge. Burination is thus much more useful as an edge reduction technique in an assemblage that includes blades compared to one containing only flakes.

In blade assemblages, burination even may be preferable to retouch in some circumstances. In order to modify the lateral edge of a blade using retouch, force must be applied repeatedly to the blade in the transverse dimension. Because a narrow blade is most susceptible to transverse snaps, there is a significant risk of breaking a blade during lateral retouch. Notably, lateral retouch, with the exception of backing, is so infrequent in blade assemblages as to have been relegated to a very minor role in most widely-used Upper Paleolithic typologies.

In contrast, in modifying a blade edge via burination, force is applied at the distal or proximal end and along the long axis of the piece. This is the strongest dimension of a blade. With the exception of backing, most retouch found in blade assemblages also is applied in this dimension, forming such tools as endscrapers, truncations, and perforators.

In addition to reducing the risk of breakage during lateral edge modification, burination also may be a more efficient means of modifying the lateral edges of blades. Numerous careful impacts are required to modify a long blade edge. The same edge can be modified by the removal of a single burin spall. This would be especially advantageous for resharpening lateral-edge cutting/scraping tools and for rapidly reducing blade edges for mounting in a socketed haft.

With respect to this latter point, there seems to be an increase in the frequency of hafted tools beginning in the Upper Paleolithic. The coeval increase in burin frequency may be a reflection of this trend. Notably, lithic assemblages containing blades, regardless of their chronological placement, generally exhibit one of two major reduction patterns. Either they contain high frequencies of backed blades (e.g., Amudian [Jelinek 1982: 1374], Howeison's Poort [Singer and Wymer 1982: 95–104], Zarzian [Olszewski 1993b]), or high frequencies of burins (e.g., Pre-Aurignacian [Jelinek 1982; Rust 1950], and various Aurignacian facies [Gilead 1991; Hahn 1970, 1972]). These forms may represent alternative ways of preparing blades for hafting. Ironically, the presence of burins may indeed be related to the greater use of non-lithic materials such as bone, antler, or wood, not because burins were necessarily used to work these materials, but because they were *hafted* in these materials.

Finally, repeated burination seems an efficient way to produce small bladelets of standardized proportions from a flake or blade. Such a flake or blade would be highly portable and could serve as both a multipurpose processing tool and a source of bladelets for compound tools. This could be especially advantageous under conditions of high mobility and/or low availability of lithic resources.

Conclusions

Burins have long been considered to have served primarily as tools for engraving or grooving. Our analysis of burins from three late Pleistocene sites, however, supports a number of recent studies in suggesting that burins also served a wide variety of other functions. This functional diversity has led us to propose that burination served as an alternative technique to retouch for modifying or removing material (i.e., spalls) from the edges of flakes and, especially, blades. Burination is most effective in this way when practiced on long, straight edges such as are found on prismatic blades, and less commonly on lamellar flakes and Levallois points. This technological characteristic more likely explains the increased frequency of burins in Upper Paleolithic and later lithic industries than does a postulated increase in the working of non-lithic materials.

The model presented here necessitates a reconsideration of the interpretation of morphological diversity among burins. It is generally assumed by many archaeologists that variability in burin morphology is primarily stylistic in origin—that is, representing culturally determined variants of more or less functionally-equivalent tools. As such, burins are widely used as markers of temporal change and cultural identity.

We suggest, however, that there is considerable functional diversity among stone artifacts reduced by burination. Hence, morphological variability likely relates as much or more to functional and technological factors as to style. As with retouched artifacts, burins could be, and probably often were, multi-functional, making specific interpretation difficult. Nevertheless, there are a number of commonly-recurring burin morphologies that often may be the end result of similar trajectories of manufacture, use, and maintenance. Given these caveats, we think it would be useful to offer a reinterpretation of widely recognized burin classes in the context of the model presented here.

Polyhedral burins often may have been bladelet cores, especially where they are found in higher frequencies and in assemblages that also contain microliths. A low incidence of breakage, and lack of burin-end and facet-edge damage or modification could also help to identify such "burin cores."

Multiple tool burins (e.g., burin/endscrapers, burin/perforators, or burin/truncations) probably represent tangs. In assemblages where these forms are more common, broken burins (especially dihedral and angle burins) also may be tangs. Such pieces could help to monitor lithic tool hafting.

Dihedral and angle burins also may have served as general purpose cutting/scraping tools. Forms with longer facet edges, on otherwise unmodified blanks, are perhaps more likely to have functioned in this way. Such "burin scrapers" also might be recognized by the presence of use damage on facet edges and retouch at facet bases. Macroscopic use damage may be minimal, however, and both facet edge damage and facet base retouch could also occur on burin tangs. Furthermore, angle burins on truncations have been interpreted as bladelet cores in the Neolithic of

SW Asia (Finlayson and Betts 1990; Gaussen and Gaussen 1965); both angle and dihedral burins also may have served as cores in other circumstances.

Transverse burins, by default, are more likely to represent engraving tools—being less suitable for tangs or "burin scrapers." Polyhedral transverse burins (carinated burins, for example) are equally likely to have been cores, however. Dihedral and angle burins could, and almost certainly did, serve as engraving or grooving tools. Those with short facet edges are, by default, more likely to have been such tools. It may be difficult, however, to separate "burin gravers" from other burin tools on the basis of macromorphology alone, without recourse to microwear studies. In fact, the frequencies of worked bone or antler, or of engraved artwork, are probably better monitors of such activities than are burins.

Although burins are but one of many lithic artifact classes, and often are a numerically minor component of many assemblages, they have gained a significance disproportionate to their frequency in the systematics of, and interpretive frameworks for, Paleolithic assemblages. Nevertheless, the more they have been studied, the more enigmatic they have become with respect to function and the meaning of morphological variability. By developing an interpretive model that integrates the diverse results of numerous functional studies and provides explanations for variability in the form and spatial/temporal distribution of burins, we hope to further the interpretation of Paleolithic assemblages and, ultimately, the understanding of the people that made and used them.

Acknowledgments

We would like to thank G. A. Clark for reading and commenting on this manuscript and Lynn Parsells for her help in the analysis. We would also like to thank four anonymous reviewers for their supportive comments and helpful suggestions. Study of the Warwasi Baradostian (levels P-Z) was made possible by a grant to Olszewski from the American Philosophical Society. This is Wadi Hasa Paleolithic Contribution No. 14, supported by grants to Clark from the National Science Foundation (BNS-8405601, BNS-9013972, DBS-9302853), the National Geographic Society (2914-84), the Chase Bank of Arizona, and Arizona State University (Office of the Vice President for Research, 90-0729).

Michael Barton is an Associate Professor in the Department of Anthropology, Arizona State University. He has done fieldwork in Spain, Bosnia, and central and western North America, and has studied Paleolithic, Mesolithic, Neolithic, and Bronze Age materials from the circum-Mediterranean region. His current research focuses on late Pleistocene and early Holocene technology, economy, and land use in eastern Spain, and evolutionary theory in archaeological explanation. Mailing address: Department of Anthropology, Box 872402, Arizona State University, Tempe, AZ 85287-2402.

Deborah I. Olszewski is Associate Anthropologist/Archaeologist at the Bishop Museum, Honolulu, Hawaii. She has worked extensively with Paleolithic, Epipaleolithic, and Neolithic remains in SW *Asia as well as Western Europe, and with the prehistoric in North America. Mailing address: 1525 Bernice St., Box 1900, Department of Anthropology, Bishop Museum, Honolulu, Hawaii 96817-0916.*

Nancy R. Coinman is Assistant Professor of Anthropology at Iowa State University. She has done fieldwork in Jordan and the SW *United States. Her current research focuses on technological changes in the Levantine Upper Paleolithic. Mailing address: Department of Anthropology, 319 Curtiss Hall, Iowa State University, Ames, IA 50011-1050.*

Aiello, Leslie

1993 "The Fossil Evidence for Modern Human Origins in Africa: A Revised View," *American Anthropologist* 95: 73–96.

Barton, C. Michael

1991 "Retouched Tools: Fact or Fiction? Paradigms for Interpreting Chipped Stone," in G. A. Clark, ed., *Perspectives in Prehistory: Paradigmatic Biases in Circum-Mediterranean Hunter-gather Research.* Philadelphia: University of Pennsylvania Press, 143–163.

Becker, Mark, and Fred Wendorf

1993 "A Microwear Study of a Late Pleistocene Quadan Assemblage from Southern Egypt," *Journal of Field Archaeology* 20: 389–398.

Begouën, Max

1926 *Bison of Clay.* Trans. Robert L. Duffus. New York: Longmans, Green, and Co.

Braidwood, Robert, Bruce Howe, and Charles Reed

1961 "The Iranian Prehistoric Project," *Science* 133: 2008–2010.

Bordes, François

1965 "Utilization Possible des Côtés de Burins," *Funderberichter aus Schwaben* (n.s.). 17: 3–4.

1967 "Considérations sur la typologie et les techniques dans le Paléolithique," *Quartär* 18: 25–55.

Büller, Hans

1983 "Methodological Problems in the Microwear Analysis of Tools Selected from the Natufian Sites of el Wad and Ain Mallaha," in M.C. Cauvin, ed., *Traces d'Utilisation sur les Outils Néolithiques du Proche Orient.* Lyon: Maison de l'Orient, 107–125.

Callow, Paul
1986 "The Flint Tools," in Paul Callow and Jean M. Cornford, eds., *La Cotte de St. Brelade 1961–1978: Excavations by C. B. M. McBurney.* Norwich: Geobooks, 251–314.

Clark, Geoffrey A., John Lindly, Marci Donaldson, Andrew Garrard, Nancy Coinman, Joseph Schuldenrein, Suzanne Fish, and Deborah Olszewski
1987 "Paleolithic Archaeology in the Southern Levant. A Preliminary Report of Excavations at Middle, Upper and Epipaleolithic Sites in Wadi el-Hasa, West-Central Jordan," *Annual of the Department of Antiquities of Jordan* 31: 19–78.

1988 "Excavations at Middle, Upper and Epipaleolithic Sites in the Wadi Hasa, West-Central Jordan," in Andrew Garrard and Hans Georg Gebel, eds., *Prehistory of Jordan. The State of Research in 1986. BAR International Series* 396. Oxford: B. A. R., 209–285.

Clark, G. A., D. Olszewski, J. Schuldenrein, N. Rida, and J. Eighmey
in press "Survey and Excavation in the Wadi al-Hasa: A Preliminary Report of the 1993 Field Season," *Annual of the Department of Antiquities of Jordan.*

Clark, J. Desmond
1983 "The Significance of Culture Change in the Early Later Pleistocene in Northern and Southern Africa," in E. Trinkaus, ed., *The Mousterian Legacy. BAR International Series* 164 . Oxford: B. A. R., 1–12.

Coinman, Nancy R.
1990 *Refiguring the Levantine Upper Paleolithic: A Comparative Examination of Lithic Assemblages from the Southern Levant.* Ph.D. dissertation, Arizona State University, Tempe. Ann Arbor: University Microfilms International.

in press "WHS 618 - Ain el-Buhira: An Upper Paleolithic Site in the Wadi Hasa, West-Central Jordan," *Paléorient* 19.

Crabtree, Don, and E. Davis
1968 "Experimental Manufacture of Wooden Implements with Tools of Flaked Stone," *Science* 159: 426–428.

Dibble, Harold L.
1987 "The Interpretation of Middle Paleolithic Scraper Morphology," *American Antiquity* 52: 109–117.

1991 "Mousterian Assemblage Variability on an Interregional Scale," *Journal of Anthropological Research* 47: 239–257.

Dibble, Harold L., and Simon Holdaway
1990 "Le paléolithique moyen de l'abri sous roche de Warwasi et ses relations avec le moustérien du Zagros et du Levant," *L'Anthropologie* 94: 619–642.

1993 "The Middle Paleolithic Industries of Warwasi," in Deborah Olszewski and Harold Dibble, eds., *The Paleolithic Prehistory of the Zagros-Taurus.* Philadelphia: University of Pennsylvania Museum, 75–99.

Dreiman, Richard
1979 *Methods in Artifact Analysis: A Study of Upper Paleolithic Burins. Contributions of the University of California Archaeological Research Facility* 42. Berkeley.

Finlayson, Bill, and Alison Betts
1990 "A Functional Analysis of Chipped Stone Artefacts from the Late Neolithic Site of Gabal Na'ja, Eastern Jordan," *Paléorient* 16(2): 13–30.

Flenniken, J. Jeffrey, and Phillip J. Wilke
1989 "Typology, Technology, and the Chronology of Great Basin Dart Points," *American Anthropologist* 91: 149–158.

Gaussen, Michel, and Jean Gaussen
1965 "Un atelier de burins á Lagreich-Néo I, Oued Tilemsi (République du Mali)," *L'Anthropologie* 69: 237–248.

Giddings, J. L.
1956 "The Burin Spall Artifact," *Arctic* 9(4): 229–237.

1964 *The Archaeology of Cape Denbigh.* Providence: Brown University Press.

Gilead, Isaac
1991 "The Upper Paleolithic Period in the Levant," *Journal of World Prehistory* 5(2): 105–154.

Hahn, Joachim
1970 "Recherches sur l'Aurignacien en Europe centrale et orientale," *l'Anthropologie* 74(3-4): 195–200.

1972 "Das Aurignacien in Mittel- und Osteuropa," *Acta Praehistorica et Archaeologica* 3: 77–107.

Hole, Frank, and Kent Flannery
1967 "The Prehistory of Southwestern Iran: A Preliminary Report," *Proceedings of the Prehistoric Society* 33: 147–206.

Hours, Francis
1974 "Remarques sur l'utilisation des listes-types pour l'étude du paléolithique supérieur et de l'epipaléolithique du Levant," *Paléorient* 2: 3–18.

Jelinek, Arthur J.
1982 "The Tabun Cave and Paleolithic Man in the Levant," *Science* 216: 1369–1375.

Keeley, Lawrence H.
1982 "Hafting and Retooling: Effects on the Archaeological Record," *American Antiquity* 47: 798–809.

Klein, Richard
1989 *The Human Career.* Chicago: University of Chicago Press.

Knecht, Heidi
1988 *Upper Paleolithic Burins: Type, Form, and Function. BAR International Series* 434. Oxford: B.A.R.

Leguay, Louis
1877 "Les procèdes employés pour la gravure et la sculpture des os avec le silex," *Bulletins de la Societé d'Anthropologie de Paris (2e ser.)* 12: 280–296.

MacDonald, Burton
1988 *The Wadi el Hasa Archaeological Survey, 1979–1983, West-Central Jordan.* Waterloo, Ontario: Wilfrid Laurier University Press.

MacDonald, B., G. Rollefson, E. Banning, B. Byrd, and C. d'Annibale
1983 "The Wadi el Hasa Archaeological Survey 1982: A Preliminary Report," *Annual of the Department of Antiquities of Jordan* 27: 311–323 and Pls. 69–72.

Massaud, J.
1972 "Observations sur l'utilisation des burins multifacettés,"

Bulletin de la Societé Préhistorique Française 69: 231–234.

Mortensen, Peder
1970 "A Preliminary Study of the Chipped Stone Industry from Beidha, an Early Neolithic Village in Southern Jordan," *Acta Archaeologica* 41: 1–54.

Moss, Emily
1978 "A Variation of a Method of Microwear Analysis Developed by L. H. Keeley, and its Application to Flint Tools from Tell Abu Hureyra, Syria. M.A. thesis, University of London, Summary," *Institute of Archaeology Bulletin* 15: 238–239.

1983 "A Microwear Analysis of Burins and Points from Tell Abu Hureyra, Syria," in M. C. Cauvin, ed., *Traces d'Utilisation sur les Outils Néolithiques du Proche Orient*. Lyon: Maison de l'Orient, 143–161.

Movius, Jr., Hallam
1968 "Note on the History of the Discovery and Recognition of the Function of Burins as Tools," in Raymond Vaufrey, ed., *La Préhistoire, Problèmes et Tendences.* Paris: C.N.R.S, 311–318.

Neeley, Michael P., and C. Michael Barton
1994 "A New Approach to Interpreting Late-Pleistocene Microlith Industries in Southwest Asia," *Antiquity* 68: 275–288.

Noone, H. V. V.
1934 "A Classification of Flint Burins or Gravers," *Journal of the Royal Anthropological Institute* 64: 81–92.

1950 "Notes on Flint Burins of the Vèzére (Dordogne) Sites," *Proceedings of the Prehistoric Society* 16: 186–191.

Olszewski, Deborah I.
1993a "The Late Baradostian Occupation at Warwasi Rockshelter, Iran," in Deborah Olszewski and Harold Dibble, eds., *The Paleolithic Prehistory of the Zagros-Taurus.* Philadelphia: University of Pennsylvania Museum, 187–206.

1993b "The Zarzian Occupation at Warwasi Rockshelter, Iran," in Deborah Olszewski and Harold Dibble, eds., *The Paleolithic Prehistory of the Zagros-Taurus.* Philadelphia: University of Pennsylvania Museum, 207–236.

1993c "Zarzian Microliths from Warwasi Rockshelter, Iran: Scalene Triangles as Arrow Components," in Gail Larson Peterkin, Harvey M. Bricker, and Paul Mellars, eds., *Hunting and Animal Exploitation in the Later Paleolithic and Mesolithic of Eurasia. American Anthropological Association, Archaeological Papers* 4. Washington D. C.: American Anthropological Association, 199–205.

Olszewski, Deborah I., Geoffrey A. Clark, and Suzanne Fish
1990 "WHS 784X (Yutil al-Hasa): A Late Ahmarian Site in the Wadi Hasa, West-central Jordan," *Proceedings of the Prehistoric Society* 56: 33–49.

Olszewski, Deborah I., and Harold L. Dibble
1994 "The Zagros Aurignacian," *Current Anthropology* 35: 68–75.

Rolland, Nicolas, and Harold L. Dibble
1990 "A New Synthesis of Middle Paleolithic Variability," *American Antiquity* 55: 480–499.

Rust, Alfred
1950 *Die Hohlenfünde von Jabrud (Syrien).* Neumünster: Wachholtz.

Sackett, James
1989 "Statistics, Attributes and the Dynamics of Burin Typology," in Donald O. Henry and George H. Odell, eds., *Alternative Approaches to Lithic Analysis. American Anthropological Association, Archaeological Papers* 1. Washington D. C.: American Anthropological Association, 51–82.

Schuldenrein, Joseph, and Geoffrey A. Clark
1994 "Landscape and Prehistoric Chronology of West-Central Jordan," *Geoarchaeology: An International Journal* 9: 31–55.

Seitzer, D.
1978 "Form vs. Function: Microwear Analysis and its Application to Upper Palaeolithic Burins," *Meddelanden Fran Lunds Universitets Historiska Museum* 2: 5–20.

Semenov, S. A.
1964 *Prehistoric Technology.* London: Cory, Adams and Mackay.

Singer, Ronald, and John Wymer
1982 *The Middle Stone Age at Klasies River Mouth in South Africa.* Chicago: University of Chicago Press.

Solecki, Ralph S.
1958 *The Baradostian Industry and the Upper Paleolithic in the Near East.* Unpublished Ph.D. dissertation, Columbia University, New York.

de Sonneville-Bordes, D., and J. Perrot
1956 "Lexique Typologique du Paléolithique Supérieur. Outillage Lithique - IV Burins," *Bulletin de la Societé Préhistorique Française* 53: 408–412.

Stafford, Barbara
1977 "Burin Manufacture and Utilization: An Experimental Study," *Journal of Field Archaeology* 4: 235–246.

Tixier, Jacques
1963 *Typologie de l'Epipaléolithique du Maghreb.* Paris: Arts et Métiers Graphiques.

1974 "Glossary for the Description of Stone Tools" (trans. Mark Newcomer). *Newsletter of Lithic Technology: Special Publication Number* 1. Pullman: Washington State University.

Toth, Nicholas
1985 "The Oldowan Reassessed: A Close Look at Early Stone Artifacts," *Journal of Archaeological Science* 12: 101–120.

Trinkaus, Eric
1986 "The Neandertals and Modern Human Origins," *Annual Review of Anthropology* 15: 193–218.

Vaughan, Patrick
1985 "The Burin-blow Technique: Creator or Eliminator?" *Journal of Field Archaeology* 12: 488–496.