BROKEN BONES, BONE EXPEDIENCY TOOLS, AND BONE PSEUDOTOOLS: LESSONS FROM THE BLAST ZONE AROUND MOUNT ST. HELENS, WASHINGTON

R. Lee Lyman

Criteria for recognizing technological and use-wear modifications have been used to identify “bone expediency tools” by archaeologists who analyze bone assemblages recovered from sites where butchering of animals took place. These criteria are here reviewed and then used to identify bone pseudotools in cervid bone assemblages completely formed by non-human processes and recovered from the blast zone around the Mount St. Helens volcano in Washington. The procedures for identifying stone tools and bone tools share similar strengths and weaknesses that seem to originate with the logical criteria used for recognizing modifications to the objects under study. Less equivocal inferential identifications of bone objects as “tools” can be facilitated by turning to the problem of constructing testable hypotheses about the way patterns of use-wear modifications to bone tools can be expected to appear in the archaeological record.

The detailed study of animal bones recovered from archaeological sites has resulted in the recognition of roughly-formed bone objects that are believed to represent tools. Many of the criteria employed to identify bone tools have been questioned (e.g., Binford 1981), and the literature contains assertions and rebuttals concerning the validity of particular identifications of bone tools (e.g., Bonnichsen 1981; Guthrie 1980, 1981). In this paper, I review the criteria used to identify one category of bone tools. In order to test the validity of the criteria, they are employed to identify bone objects in two bone assemblages having formational histories that do not involve humans. However, the test yields an identification of these objects as pseudotools (objects modified by natural processes that result in items that look like tools; e.g., Brain [1967]). Therefore, the criteria and techniques currently used to identify stone artifacts are also reviewed, and the similarities and differences between these and the techniques used to identify bone tools are noted. Finally, suggestions are presented for a more valid approach to the problem of identifying bone tools.

CRITERIA FOR BONE TOOL IDENTIFICATION

Basically, two lines of evidence are used to identify as tools particular bones in a bone assemblage recovered from an archaeological site. These lines of evidence are derived from the context and modification of the particular bones. Since context provides a different kind of evidence from modification, and some bone objects not discovered in an archaeological context have been identified as tools, context will be considered separately in a later section of this paper. Here, discussion will be restricted to the kinds of bone modifications that have been used as criteria to define the category of tools known as “bone expediency tools.”

Eileen Johnson states that

The expediency concept now applied to these bone butchering tools is defined within a technological, not functional, framework. Expediency tools were made quickly and efficiently regardless of their performance. These tools were made during butchering activities from bones of animals being processed, were used in the processing, and then were discarded with the rest of the faunal debris. The concept reflects localized manufacture. With such a readily abundant source of tool material, only tool production knowledge need be brought to each kill [Johnson 1980:83–84].

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Bone objects that have been identified as "bone expediency tools" have been found in many sites covering the Paleoindian through later periods and in numerous geographic localities (see references cited below).

The criteria employed to identify a bone as an expediency tool are derived from a model concerning the use-history of tools. Although the use-history is partly conjectural, criteria have been derived from the model, and employed as though definitive, to make possible the identification of "bone expediency tools." A flow chart depicting the conjectural, possible use-histories of bone expediency tools has been derived from the literature (Frison 1970, 1971, 1973, 1974, 1978, 1982; Johnson 1978, 1980, 1982; Johnson and Holliday 1980, 1981; Sadek-Kooros 1972, 1975; Wheat 1979, 1982), and is presented in Figure 1. This flow-chart depiction of the possible use-histories is,
necessarily, ad hoc, and thus may be imprecise to some degree. The flow chart does, however, reflect
my perception of the published discussions. Each step in the flow chart will now be discussed, and
the modifications to the bones represented there will be summarized. Keep in mind that these are
precisely the modifications that have been used as criteria to identify bone expediency tools.

1. Only bones of appropriate structure, weight, and strength were employed as expediency tools. While no formal list of “appropriate” bones is presented in the literature examined, a cursory review of bison bone objects identified as “bone expediency tools” suggests that all bones of a skeleton could be employed as expediency tools, with the exception of the carpals, tarsals, phalanges, vertebrae, and most cranial bones. The literature examined suggests these exceptions were excluded from use as expediency tools because they lack appropriate strength, thickness, shape and balance, and size and weight (e.g., Frison 1973, 1974; see Corbin [1975] and MacGregor and Currey [1983] for examples in other contexts). Weight and balance requirements may be met, however, by using a joint that includes several articulated bones. Therefore, any bone may be a part of a bone expediency tool. Appropriate bones thus “include about any bone with a desireable edge on one end and a proper handle on the other” (Frison 1973:34).

2. The literature suggests that bones were broken, either “purposefully” for eventual use as tools, or “fortuitously” (e.g., Frison 1973:34). While the examined literature is not entirely clear on the entailments of this distinction, it appears that “fortuitous” fractures include those fractures that occurred in the course of activities like butchering and/or marrow extraction; i.e., activities not directed specifically toward the production of bone tools. There are two problems in this distinction of “fortuitous” and “purposeful” fracture. First, if a bone is broken to extract marrow (e.g., Noe-Nygaard 1977) or as part of the meat extraction process (e.g., Lyman 1978), the bone has been purposefully (not fortuitously) broken, albeit not with the intent of making a bone tool. The terminology employed in the distinction is ambiguous. The second problem is that the criteria used to distinguish purposeful (also called “deliberate” [Frison 1970, 1973] and “controlled” [Johnson 1982; Wheat 1982]) from fortuitous breakage seem to be controversial. For example, Frison (1974) suggests that fractures resulting from marrow extraction will display multiple flake scars on the fracture edge of the long bone diaphysis, while a single flake scar indicates purposeful fracture directed toward obtaining a bone expediency tool. Bonnichsen and Will (1980), Johnson (1982) and Stanford (1979) seem to imply exactly the opposite when they suggest that multiple flake scars indicate purposeful breakage of bones to be used as tools. These problems of contradictory definitive criteria and ambiguous terminology are not of great moment, however, because of the third step in the conjectural use-history of bone expediency tools.

3. “Breaks serve as the working edge” (Frison 1971:272). When a bone is fractured, a usable break, generally considered to be a spiral fracture with a point or sharp edge, may result (Frison 1982; Johnson 1982; Wheat 1982). Such a fracture might be thought of as the first step in tool manufacture if the bone was broken to make a tool, or was purposefully broken as a part of the tool manufacturing process. Fortuitous fractures (see Step 2 above) can, however, also result in broken edges that are usable as tools. Such incidental breaks should not be considered results of manufacturing processes because they did not result from tool production related breakage. Most breakage related to bone tool production “was similar to breakage which occurred while opening long bones for marrow” (Frison 1982:160), and the literature correctly recognizes that “controlled breakage alone is not evidence of tool use” (Johnson 1982:147).

4. Even though a bone is purposefully fractured in an attempt to produce a tool, the result may be a non-usable break. The literature examined does not clearly indicate what a non-usable break may be, but by implication it would seem to consist of a non-spiral fracture or a spiral fracture with a non-usable edge morphology, such as the lack of a point or sharp edge. Such non-usable fracture edges may display no evidence of use as a tool (see Step 9 below).

5. Because fracturing of bones may not be directed towards producing bone tools (i.e., can be “fortuitous”), fracture incidental to activities other than tool production may regularly result in non-usable breaks in the bones, but this is not known with any certainty.

6. Fracture unrelated to tool production may result in a usable broken edge morphology (Frison
Archaeological evidence of manufacturing activity has been described as consisting of chipped fracture edges (chipped to sharpen the edge), ground fracture edges (ground to obtain a desired shape), seriated fracture edges (seriated to sharpen the edge) and the accumulation of "detritus" (Frison 1973:34; Johnson 1980:84, 1982:147; Wheat 1979:138). Precisely what "detritus" might consist of is not specified (but see Stanford et al. [1981] and references therein for some possibilities).

Bones with usable breaks may be used without additional manufacturing modifications. "The manufacturing of bone butchering tools involved only bone breakage" (Frison 1982:160). "A utilized item is an element that was unmodified before use, simply taking advantage of broken edge" (Johnson 1982:147). Archaeologically visible traces of use-wear modification have been described as polish, rounding, smoothing, and microflaking of edges and points, and striations (Frison 1974:56; Johnson and Holliday 1980:95; Wheat 1979:138). Such modifications may be restricted to the fracture edge or edges; they may be only on or near the point of the spiral fracture; and/or they may extend beyond the fracture edge onto the diaphysis. Striations may be perpendicular or parallel to the working edge. As with stone tools, bone tools may be broken by use, resharpened, and used again (Wheat 1979:138). "The fact that resharpening took place shows that these were a valued tool" (Wheat 1979:143).

Bones with usable breaks may be modified by manufacturing activities prior to their use. "Some bone tools bear evidence of light to moderate grinding to give definite shapes to the working edge while others utilize a broken edge with no modification" (Frison 1970:26).

Bones which have been broken and then modified by manufacturing activities are used as tools. "Working edge preparation by deliberate abrasion against rough surfaces with wear superimposed can be detected on some bone surfaces, while others manifest only wear patterns over the breaks on the bone" (Frison 1973:34).

Use of the bone expediency tools may produce use-wear modifications of various types on the working ends and/or edges. "Major criteria are wear polish, damage use flake scarring, and rounded or worn surfaces along the working edge. These characteristics appear in various combinations with each other" (Johnson 1982:147). "The kind of use to which a chopping tool of bone was subjected in butchering seldom resulted in the development of noticeable wear patterns. Satisfactory evidence of use is present in only a small number of tools" (Frison 1982:165).

A variable of importance equal to that of "kind of use" is duration or intensity of use. "Any bone collected in antiquity for use as an implement but abandoned or lost before sufficient use to work up a sheen might be interpreted as unused butchering refuse" (Gilbert 1979:196). The problem of sufficient artificial modification to an object to permit the unequivocal identifiacaion of that object as humanly modified permeates all aspects of archaeology (see below). Another type of modification to a bone used as a tool occurs in relation to the handling of the bone during use. "Holding the bone tool resulted in a polish over the parts of the tool used as a handle" (Frison 1982:164). Gilbert (1979:184–185) recognized a similar phenomenon in a faunal assemblage from the Near East and suggested "handling of bone tools would likely create a sheen in proportion to the length of time the tool was used." He goes on to point out that this handle-polish would only be distributed over exposed periesteo bone surfaces.

The bone expediency tool is discarded essentially in the location of its manufacture and use;
that is, it is discarded with the rest of the faunal debris when it is no longer needed, or when it is "worn out" (Johnson 1980). Opinion differs as to whether bone expediency tools were ever curated (Binford 1979). Some archaeologists believe that these tools were made from the bones of animals being processed (e.g., Bonnichsen and Young 1980; Johnson 1982; Wheat 1982) while others believe that these tools were either brought in to the butchery site or were derived from bones of animals killed during previous hunts at the same site (Frison 1982). This issue will be considered further in the CONTEXT discussion below.

Many of the traces of manufacture and use-wear modification mentioned above have been seriously questioned (Binford 1981). Further, systematic methods for distinguishing modifications made to bones through manufacture from modifications made through use are only in the developmental stages (Geniesse 1982). The utility of the conjectures embodied in the flow chart depicting the potential use-histories of bone expediency tools (Figure 1) for the identification of such tools is therefore suspect. To assess the criteria that are derived from the model and used to identify bone expediency tools, our discussion will now turn to the employment of those criteria to identify bone objects in samples of bones with formational histories that do not involve people.

THE MOUNT ST. HELENS CERVID BONES

Recent research around Mount St. Helens, a strato-volcano in south-central Washington, provides data relevant to the issue of identifying bone expediency tools. The May 18, 1980 eruption of this volcano resulted in the death of many cervids living within a 15-km distance to the north of the volcano. Remains of these cervids were collected in the late summer and early autumn of 1981, while human access to the area devastated by the eruption—the "blast zone"—was still restricted (Taber et al. 1982). Numerous bones of deer (Odocoileus hemionus) and elk (Cervus elaphus) were collected and have been analyzed from a taphonomic perspective (Lyman and Livingston 1983). The bones recovered from two loci will be considered here.

The Assemblages and the Pseudotools

An assemblage consisting of 343 post-natal elk bones and 5 foetal elk bones was recovered from the locus known as "Site 2," and 94 post-natal elk bones and 13 foetal elk bones were recovered from the locus designated "Site 4." The minimum number of individuals is one foetus and six post-
natal individuals at Site 2, and two foetuses and one post-natal individual at Site 4. Carnivore gnawing is apparent on some of the bones, but overall the damage to the bones that is attributable to carnivores is neither extensive nor intensive (see Lyman and Livingston [1983] for a complete discussion), particularly when compared to published studies where prey mortality was attritional (e.g., Haynes 1980).

Eleven long bones in the Site 2 assemblage and four long bones in the Site 4 assemblage are spirally fractured. (Note that the definition of a “spiral fracture” is presently being evaluated; see Morlan [1980:45–49] and Shipman [1981]. I have, for the purposes of this paper, adopted the definition of spiral fracture presented by Haynes [1983:104].) The bones that are spirally fractured are one humerus, three radii, three metacarpals, two femora, four tibiae, and two metatarsals. These are all “appropriate” bones according to the criteria derived from the conjectural use-history of bone expediency tools. Further, some of the fractures resulted in pointed ends and others resulted in sharp fracture edges, and these, too, match the criteria derived from the model.

Post-fracture modifications to several fracture edges are apparent. One proximal metatarsal fragment from Site 2 has a point on the diaphysis fragment that is markedly rounded, and the edges of the fracture adjacent to the point are also smoothed and rounded (Figure 2). The point on the proximal diaphyseal fragment of a tibia from Site 2 has microflaking along the adjacent edges (Figure 3). A fragment of humerus from Site 4 also shows extensive flaking on the fracture margin of the distal diaphysis (Figure 4). The three specimens just described display evidence congruent with criteria derived from the use-history model for bone expediency tools, and they closely resemble specimens previously taken from archaeological sites and identified as “bone expediency tools” (e.g., Frison 1982; Johnson [1982] and references therein). In the case of the bones recovered from the Mount St. Helens blast zone, it certainly was not human intervention that created the modifications to the fractured edges. None of the available evidence suggests that the modifications were a major result of the activities of scavenging carnivores (Lyman and Livingston 1983). The probable causes of the modifications will be considered below.

It has been argued elsewhere that finding the broken point of, for example, a “tibia chopper expediency tool” embedded in the medullary cavity of, say, a femur, would constitute evidence for the correct identification of bone expediency tools (Frison 1974, 1978). The metacarpal of the
mature elk at Mount St. Helens Site 4 was spirally fractured, and parts of the diaphysis were embedded in the medullary cavity (Figure 5). Some of these fragments of diaphysis would be classified as "unidentifiable long bone" if they did not so readily fit onto the fracture edge of the metacarpal diaphysis. This specimen emphasizes, nonetheless, an important point. Diaphyseal fragments of a bone can become embedded in the medullary cavity of that bone without human intervention. The broken points of suspected bone choppers should, therefore, be closely and carefully identified, and can perhaps only be considered possible bone tools if they represent a skeletal element different from that in which they are embedded.

Taphonomy

The taphonomic history of the Mount St. Helens cervids is quite probably as follows: The cervids constituting sites 2 and 4 were exposed to the explosive shock wave of the volcanic eruption. This shock wave literally hurled the cervids to their recovery locations, along with trees and other debris. Fracture of the cervid bones was caused by the shock wave, falling timber, falling pumice blocks, and/or the impact of the carcasses on the ground surface. The apparent polishing and rounding of the fracture edges may have been caused by abrasion from shifting volcanic ash particles (cf. Brain 1967; Shipman and Rose 1983). Trowels used for excavation in the blast zone were dulled more rapidly by the volcanic ash in which the bones lay than by any sand or silt of an archaeological site. There is no evidence suggesting that carnivore gnawing created rounding or flaking along fracture edges. The microflaking of the fracture edges and embedding of diaphyseal fragments in the medullary cavity probably occurred as a result of the twisting of fracture edges of the same bone against one another as the carcass hurtled through the air and/or as a result of the carcass impacting the ground. Similar kinds of fracture processes and features (e.g., one piece of a broken object removing flakes from another piece of that object by rubbing and crushing together) have recently been proposed for lithic projectile points damaged and broken upon impacting a target (Bergman and Newcomer 1983). That the Mount St. Helens specimens described here closely resemble some bone specimens from bison kill sites that have been identified as "bone expediency tools" suggests that the particular characteristics of fracture type and fracture edge modifications now used as criteria to identify these tools may result naturally from the events culminating in a bison kill, particularly at jump sites.
Figure 5. Spirally fractured metacarpal. The fragments of diaphysis embedded in the medullary cavity are parts of this metacarpal that readily fit the fracture edge shown.

Other Criteria

It might be argued that some kinds of butchery or tool marks provide another line of evidence to consider (Frison 1978, 1982). Many of the kinds of damage to bones that have been attributed to human butchery practices in general, and to the use of bone expediency tools for butchering in particular, have, however, been shown to result from carnivore activity as well (for example, compare Figure 6 in Haynes [1980] to Figure 8.6 in Frison [1978] and Figure 3 in Frison [1982]). Some of the damage to the Mount St. Helens cervid bones can be attributed to scavenging carnivores (Lyman and Livingston 1983). No such damage can be related to the fracture edge modifications described above, and none of the carnivore-related damage is similar to reported damage patterns attributable to human butchering activities (Binford 1978, 1981). The possibility does exist, therefore, that some marks on bones from archaeological sites do represent tool marks and can be shown to represent tool marks in an unequivocal manner (see Lyman [1984], Shipman [1981], Shipman and Rose [1983], and Walker and Long [1977] for first approximations).

Another line of evidence that might be called upon to argue for human intervention is the frequency of spirally fractured bones in an assemblage (e.g., Bonnichsen 1979). What is assumed here is that bone assemblages affected by human activities will have higher frequencies of spirally fractured bones than assemblages not so affected (see Bonnichsen [1979] and Haynes [1983] for more complete discussions). If this assumption is valid, the Mount St. Helens sites 2 (N spiral fractures = 11) and 4 (N spiral fractures = 4) may contain too few spiral fractures relative to the total bone counts to be considered "archaeological" and might, instead, be considered "paleontological." Indeed, the mere presence, let alone frequency, of spirally fractured bone is an equivocal indicator of human intervention (see Haynes [1983] and Myers et al. [1980] and references therein). Research is continually refining our understanding of bone fracturing as finer and finer details of fracture morphology are studied (e.g., Morlan 1980; Shipman 1981), and it is clear that many assumptions in bone tool analysis are too simplistic.

CONTEXT

Frison (1973:85) suggests that "many bone expediency tools were so crude that in many contexts they would have been unrecognized as tools altogether." He elaborates: "use of bone expediency tools is difficult to demonstrate indisputably in contrast to the stone tools whose use is accepted
because of context” (Frison 1974:52). That stone objects are at least occasionally identified as tools or artifacts on the primary basis of “context” is exemplified by the following statement by Glynn Isaac (quoted in Simpson [1980:19]) concerning the Calico Hills lithic objects, which will be considered further below: “A great many of the objects would arouse no comment if they were found in normal archaeological situations.”

As has been shown in the preceding sections of this paper, bone expediency tools “have been difficult to recognize because they lack the evidence of manufacture that results from cutting, grooving and abrading seen on the more familiar types of tools such as awls and needles” (Frison 1982:160). It was only after a knowledge of the specific butchery tasks that had to be undertaken became available (derived from butchery experiments) that bone expediency tools were recognized as a possible archaeological phenomenon. They were subsequently identified in archaeological contexts (Frison 1982; Johnson 1982; Wheat 1982). I have shown above that the admissibility of certain types of bone modification as criteria definitive of bone expediency tools is highly suspect. The one line of evidence called upon to argue for the presence of bone expediency tools which has not yet been considered is, of course, “context.”

*Context,* in the quotations above, means archaeological context. Context denotes an object’s spatial location and that object’s association with other objects, which may include both cultural materials such as artifacts, and natural materials such as sediments. An archaeological context is produced by a combination of natural and cultural processes operating in a delimited geographic area over some specifiable temporal span (e.g., Schiffer 1972; Wildesren 1973). Consequently, an archaeological context is regularly treated as a unique phenomenon in an otherwise natural landscape, and is considered as being equivalent to a “site.” Of course, one of the most easily recognized indications of an archaeological context, or site, is the presence of artifacts (an object owing any of its attributes to human activity). When unquestionable artifacts are discovered, the immediate inference is that the location of the discovery represents an archaeological context, and therefore a site. When unquestioned artifacts are found, non-artificial or natural attributes that might distinguish an archaeological context from a natural context are seldom investigated systematically. A primary definitive criterion of an archaeological context, and consequently a site, is, then, the presence of artifacts, most often lithic artifacts. If the site is defined, so is the context—it is an archaeological context. It seems, therefore, that the presence of (stone) artifacts is often used to define an archaeological context, and such a context is in turn used to define the artifactual status of other objects (e.g., bone expediency tools) (see also Binford [1981:4–8]).

The preceding statement describes a circular pattern of reasoning and borders on tautology. It is no doubt an oversimplification. However, it introduces factors that must be considered, particularly when unquestioned stone tools are rare or absent. Stone tools do seem to be quite rare relative to the number of bones recovered from kill sites (Table 1). Bone expediency tools are even rarer than stone tools in such contexts. Statistical analyses of the ratios of bones, bone tools, and stone tools are not possible, however, because exact frequencies of bone and stone tools have not been published in comparable form, and because many of the values given in Table 1 are approximations. It is nonetheless interesting to note that, in general, as the number of identified bones increases, so do the numbers of stone tools and bone expediency tools. This might be expected. When there is more meat to butcher, more tools may be required to get the job done. Further, it is possible that when bone assemblages are small, no stone tools may be found due to their curation; rather, only bone expediency tools may be found. This fits well with the technological conception of bone expediency tools: one of their advantages is that the tools themselves need not be carried to the butchery site, only the knowledge of how to make them (Bonnichsen and Young 1980; Johnson 1982).

Opinions differ regarding the notion that “bone butchering tools could have been made from the limb bones of animals undergoing processing” (Bonnichsen and Young 1980:126). On the basis of butchering experiments, Frison has recently concluded that

these bone tools were most likely brought to the butchering site along with the rest of the butchering tool assemblage. It is difficult to remove a tibia, for example, from one animal and prepare it for immediate use on the next animal. The bone needs to be cleaned of flesh and muscle and somehow dried sufficiently to provide a tool that can be handled properly. A tibia that has been laid to dry for a few days, weeks, or even
Table 1. Frequencies of Stone Tools, Bones (number of identified specimens; NISP), Individual Animals (minimum number of individuals; MNI), and Bone Expediency Tools Recovered from Selected Sites.

<table>
<thead>
<tr>
<th>Site</th>
<th>Number of Stone Tools</th>
<th>NISP</th>
<th>MNI</th>
<th>Number of “Bone Expediency Tools”</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jurgens Area 1</td>
<td>1,550+</td>
<td>2,526</td>
<td>31</td>
<td>common (31+)</td>
<td>Wheat 1979, 1982</td>
</tr>
<tr>
<td>Area 2</td>
<td>410+</td>
<td>179</td>
<td>2</td>
<td>rare-occasional (13+)</td>
<td></td>
</tr>
<tr>
<td>Area 3</td>
<td>80+</td>
<td>3,028</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hawken</td>
<td>71</td>
<td>100±</td>
<td>4+</td>
<td></td>
<td>Frison, Wilson and Wilson 1976</td>
</tr>
<tr>
<td>Bonfire Shelter,</td>
<td>21</td>
<td>756</td>
<td>12</td>
<td></td>
<td>Dibble and Lorrain 1968,</td>
</tr>
<tr>
<td>Bonebed 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Johnson 1982</td>
</tr>
<tr>
<td>Casper</td>
<td>100+</td>
<td>5,385</td>
<td>77</td>
<td>37±</td>
<td>Frison 1974</td>
</tr>
<tr>
<td>Lubbock Lake</td>
<td>10</td>
<td>500±</td>
<td>6</td>
<td>4</td>
<td>Johnson and Holliday 1980</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>170±</td>
<td>7</td>
<td>1</td>
<td>Johnson and Holliday 1981</td>
</tr>
<tr>
<td>St. Helens 2</td>
<td>0</td>
<td>348</td>
<td>7</td>
<td>5+</td>
<td>this paper</td>
</tr>
<tr>
<td>St. Helens 4</td>
<td>0</td>
<td>107</td>
<td>3</td>
<td>2+</td>
<td>this paper</td>
</tr>
</tbody>
</table>

a year can be very easily transformed into a tool. Bones from previous kill events should have been plentiful and available [1982:166].

In direct contrast, experimental butchering carried out by Stanford, Bonnichsen and Morlan (1981: 439) led them to suggest that "the adaptive advantage of bone tools is that they may be made rapidly at the butchering station from the bones of the animal undergoing processing by the same principles that are used for working stone" (emphasis added). While their experiments indicated that bone tools were inadequate for performing some butchery tasks such as cutting through the hide, bone tools were found to be highly effective for other butchery tasks. Similar conclusions were reached by Frison (1982). Such differences of opinion on the locational and material origins of bone expediency tools in sites point out some of the difficulties inherent in constructing a conjectural use-history for these tools and deriving definitive criteria from such a use-history.

The differences of opinion are just that—differences of opinion based on limited experimental data. None of the authors involved has suggested how either opinion might become a working hypothesis or what archaeologically visible test implications of such an hypothesis might entail. I suggest that the construction of articulation nets (Schild 1976) could help distinguish which “opinion” might be reflected in a particular archaeological site. For example, matching a bone object identified as a bone expediency tool with the detritus resulting from its manufacture may tell us much about the locational origins of the bone object (cf. Johnson 1982). Another line of evidence to explore involves identifying the taxon of animal represented by bone tools. If the bone tool represents, say, a camel, and was found in a mammoth kill site (cf. Frison 1982), then the obvious inference is that the tool was brought to the kill site. The scope of this paper precludes further elaboration of this issue, but I suspect that much potential information has not been fully exploited.

The point of the above considerations of context and frequency of “bone expediency tools” is simple. The criteria used to identify bone tools are equivocal, particularly with reference to bone assemblages that lack associated stone tools. Assemblages of bones like those from Old Crow (Bonnichsen 1979; Morlan 1980) will therefore continue to have debatable significance concerning human prehistory. It remains to consider how stone objects are identified as tools, and to develop a more valid technique for the recognition of bone tools.

THE IDENTIFICATION OF TOOLS

Bone Expediency Tools

The conjectural use-history of bone expediency tools depicted in Figure 1, and the criteria extrapolated from that use-history, are employed to identify bone expediency tools in the archaeological record within a taphonomic framework (cf. Bonnichsen 1982). It is perhaps because both the model
and the criteria address the processes through which these tools are formed that the criteria can be used to identify bone expediency pseudotools in non-archaeological bone assemblages such as those constituting the Mount St. Helens cervid bone assemblages.

The basis of the problem lies in the definition of bone expediency tools. Given a set of definitive criteria for bone expediency tools (derived from Figure 1), whenever an object displays these criteria, that object—by definition—is a bone expediency tool. This is tautological. For example, Sadek-Kooros (1972:370), in an early effort to recognize bone tools, offered the following “hypothesis”:

Bone broken through natural agencies or through random human breaking does not accidentally result in formal categories; such categories reflect purposeful fracturing of bone with the objective of producing specific shapes. The cause of a patterned breakage is thus the intentional fracturing of bone by people.

Because she was able to specify formal categories of experimentally broken bones, Sadek-Kooros believed she had confirmed her hypothesis. The hypothesis was then used as a definition for the purpose of identifying bones found in an archaeological context as having been broken by people. The definitive criterion—formal categories of fragments—is illogical because it misuses principles of systematics (e.g., Dunnell 1971). More importantly, given the definitive criterion, specimens from many assemblages of naturally broken bones could be identified as broken by people simply because the broken bones could be placed in formal categories. The problem in Sadek-Kooros’s work is identical to that found in the identification of “bone expediency tools.” Definitive criteria for a category of phenomena are specified, the criteria are used to identify objects, and the objects displaying the definitive criteria are said to be members of the defined category of phenomena, which, of course, they are by definition.

Stone Tools

The logical parallels between the establishment of criteria for the identification of stone and bone tools respectively make it instructional to review briefly the approaches to identification of stone tools commonly used by archaeologists. Ascher and Ascher (1965:243) pointed out nearly 20 years ago that

Stone is ubiquitous in the world; purposefully [human] shaped stone, as compared to stone shaped by natural agencies, is rare. The farther back in time, the more unsophisticated and the closer to natural forms the forms created by man are likely to be. How to recognize the very rare purposefully shaped stone in the midst of stones shaped by natural agencies is an unsolved problem for those seeking traces of early man.

There are two key elements anticipated in this statement and elaborated on in the remainder of the Aschers’ paper. First, stones shaped by people are “purposefully” shaped; that is, flaking, for instance, is “repetitive, systematic, planned and controlled” (Ascher and Ascher 1965:244–245). The second key element concerns what I will here term primitiveness, and involves both the sophistication and degree of modification to the stone object. As the Aschers correctly point out, the less the degree of sophistication of the modification, the more tenuous the identification of a stone object as a tool.

These issues (purposefulness and sophistication of modification) are at the heart of the problem of recognizing stone tools (e.g., Brewer 1973; Haynes 1973a, 1973b; Wade 1973), and are also, to a significant degree, the basis for defining what we call “sites” (e.g., Foley 1981; Isaac 1981; Wildesden 1973). Binford (1981:4–8) has provided an historical overview of the use of the purposefulness and sophistication (“redundant patterning producing a result to a design or plan”) arguments in archaeology.

Purposeful shaping of an object prior to its use as a tool is here termed manufacturing modification (MM). That MM occurs in varying degrees can be illustrated by comparing a Clovis-style projectile point to a lithic “instant tool” (Gould 1978). The former object displays patterned flake scars (relative to location) that have been purposefully created in order to produce a tool; the object displays a high degree of MM. Lithic instant tools are created when the need for a stone tool arises and raw materials are immediately at hand. Lithic instant tools may or may not undergo MM prior to use, and may or may not be manufactured or worn by use into distinctive shapes (Gould 1978); these objects display a low degree of MM. This last statement brings up several important points. First, MM is not always required prior to the use of a stone object as a tool (here, lithic instant tools are...
quite similar to bone expediency tools; in fact, Figure 1 could probably apply with equal credibility to lithic instant tools and bone expediency tools). What I will here term use-wear modification (UWM) is not purposeful modification in the sense of MM, but rather is the incidental result of an object’s being used as a tool. Finally, neither MM nor UWM need result in patterned or sophisticated modification of an object. A tool may, therefore, appear quite “primitive”; that is, it may lack a significant degree of modification even though it was made (MM) and used (UWM) by people. Whenever a tool appears “primitive,” context is used as a definitive criterion (cf. Binford 1981:6, 8).

The debate over the identification of the pre-Wisconsinan Calico Hills site (Simpson 1978) hinges on the validity of the identification of stone objects from that locality as tools (cf. Brewer 1973; Haynes 1973a, 1973b; Wade 1973). Arguments center around the patterning of modifications to the stones, the types of lithic materials that display evidence of modification, and the distribution (context and association) of the objects involved (e.g., Leakey et al. 1968; Simpson 1980, 1982). It is clear from the arguments—and is admitted by both sides (e.g., Haynes 1973b; Wade 1973)—that “opinion” plays a large role in the identification process. This is a consequence of the fact that “there appears to be a gradual transition between what are considered to be artifacts, probable artifacts, possible artifacts, and non-artifacts” (Haynes 1973a:307). What are lacking are distinctive, definitive criteria for determining which objects are to be subsumed under the “possible artifact” category.

Two recent studies of the Calico Hills lithic objects attempt to resolve the issue of what probabilistic signature criteria might be. Duvall and Venner (1979) emphasize that morphological attributes, both individually and in sets, differentiate kinds of objects. They measured seven attributes of two samples of Calico Hills lithics, one sample consisting of objects reported to have been modified by people and the other sample consisting of lithics believed to have been modified only by natural processes. Payen (1982; Taylor and Payen 1979:264–274) measured only the flake angle (angle between the platform and ventral face of the specimen) on 54 samples of lithics, some of which were humanly modified and others which consisted of naturally modified lithics. He compared these samples statistically to samples of lithic objects from Calico Hills. Both studies clearly showed that the Calico Hills specimens more closely resemble naturally modified than humanly modified lithic objects. Duvall and Venner (1979:462) conclude that “the Calico Tools are members of the population of naturally flaked rocks” (emphasis added). Payen (1982:201; Taylor and Payen 1979:273) cautions that his approach “suggests the Calico specimens are geofacts” (emphasis added) and encourages further testing of the validity of his technique of artifact identification. While the conclusions of the two studies are similar, they differ in the degree of faith the investigators placed in their statistically defined, or probabilistic, signature criteria. Neither study demonstrates that the Calico Hills lithic objects are not tools, but only that these objects more strongly resemble the control samples of naturally broken rocks than the control samples of artifacts. As Bell (1982:67) notes, “purely correlative relations are normally confined to application over a given range of data and, if they are also statistical, allow for improbable but possible exceptions” (see also Willer and Willer [1973]).

Gruhn and Young (1980) correctly point out that simply because the Calico “tools” are not like a sample of other lithic objects generally accepted to be tools does not mean the Calico lithics are not tools. Patterson (1980:376) elaborates on this and notes that “there can be a variety of reasons why attributes of flakes in Calico and Paleoindian assemblages are statistically different, none of which are related to the question of manufacture by man.” These criticisms reduce to asking if variables relevant to determining whether or not humans modified the Calico lithics were used in Payen’s (1982) and Duvall and Venner’s (1979) analyses (Patterson 1980). While Patterson’s (1983) recent paper on choosing variables relevant to the identification of stone tools is worthy of serious attention, it must be emphasized that he commits the same errors he criticizes. In particular, Patterson (1983) advocates a set of variables with no substantive justification for their relevancy; he does not outline techniques by which his variables may be objectively measured and evaluated, and he dismisses alternative variables suggested by other archaeologists by expressing opinions of the original investigators’ (lack of) professional competency.
Approaches to Tool Identification

Individual stones are identified as tools when they display modifications that can be attributed to human activity (MM or UWM). Debate over the accuracy of possible identifications hinges on the definitive criteria employed to make the identification. It is here—in the establishment of relevant, distinctive definitive criteria—that problems are encountered. Specifically, equifinality—"the property of allowing or having the same effect or result from different events" (Merriam 1961:761)—must be controlled.

Ascher and Ascher (1965) distinguish three approaches to identifying stone tools. These are observation of natural and cultural (ethnoarchaeology) agencies and processes, simulation of natural processes, and imitative experiments of cultural processes. Bonnichsen (1982) lists four approaches to producing identifications of bone tools and distinguishing these from bone objects that are not tools. The four are observation of naturally occurring modified bones (e.g., Behrensmeier 1978), simulation of natural and cultural processes by experiment (e.g., Bonnichsen 1973; Miller 1969, 1975), making inferences from modern bone assemblages (e.g., some data in Binford [1981]), and making inferences based on prehistoric assemblages (e.g., Briuer 1977; Gilbow 1981; McGuire 1980). All seven of the above listed approaches are actualistic in nature and have roots in the uniformitarianist paradigm of the nineteenth century (Gould 1965, 1967, 1979; Hooykaas 1970; Rudwick 1971; Simpson 1970). Actualistic approaches are followed today in geology (Watson 1969) and take various forms in archaeology (Dunnell 1982), the most common involving ethnographic analogy (Ascher 1961) and ethnoarchaeology (Gould 1980, ed. 1978).

The procedures for tool identification involve the use of criteria derived from actualistic research (e.g., for lithics: Patterson [1983]; for bones: Binford [1981], Bonnichsen [1973, 1979], Frison [1982], Johnson [1982], Sadek-Koors [1972, 1975], and Wheat [1982]). Often, however, when several sets of actualistic data are examined, sets of similar "definitive" criteria may be derived even though they may originate from the observation of different processes. Controversy then ensues as to which set of criteria is to be considered the more "definitive"; that is, which set of criteria provides the most correct identification (see Binford [1967, 1972] and Munson [1969] for a classic example in ethnographic analogy; see Binford [1978, 1981] for examples concerning bones). This problem—equifinality—has been discussed at length by several people (Binford 1981; Gifford 1981; Grayson 1982; Shipman 1981). It is apparent, on the basis of the analysis of the Mount St. Helens cervid bones presented above, that equifinality has not been adequately dealt with by those who identify "bone expediency tools." It is with this fact in mind that I offer the following discussion.

DISCUSSION

Bonnichsen (1982:141) cautions against the uncritical acceptance of "what if" arguments that purport to invalidate the identification of bone objects as tools (see Brewer [1973] for a clever characterization of "what if" arguments concerning the Calico Hills stone objects). To paraphrase Haynes (1983:113), I have not disproven the identifications of "bone expediency tools" in bison kill sites as such; I have, however, illustrated that equifinality is insufficiently controlled as yet, and that published identifications of "bone expediency tools" should be viewed as only one possible interpretation of particular bone objects.

"What if" arguments arise regularly by virtue of the lack of distinctive, truly definitive criteria. Bonnichsen (1982) therefore urges that future attempts to identify bone tools must be geared towards establishing truly definitive and distinctive criteria. Binford (1981:26) labels these criteria "signature patterns" (see also Gould [1980]), and defines them as follows: "a diagnostic signature criterion is one that is constant and unique and that discriminates one modifying agent or set of agents from another." He goes on to point out that, regularly, even when "signature criteria" are available, only "an inference of high probability" concerning the identification of the agent(s) of modification is possible (1981:27). It should be noted that when the inference is but highly probable, no signature patterns, as defined, have been established. This may be why Binford's (1981) interpretations of the Olduvai Gorge materials are questionable (cf. Bunn 1982); Binford fails to produce the "if and only if" statements (Grayson 1982) of which signature patterns must consist by definition.
There are two interrelated alternatives to diagnostic signature patterns of the “if and only if” type for postulating the identification of an agent or object. Binford (1981:83) discusses arguments from elimination, in which “(a) all the potential causes or agents are known and listed and (b) all but one of those listed are not the cause of the phenomenon in question.” Binford points out the similarities between argument from elimination and multiple working hypotheses (the second alternative), the latter of which has been advocated by Bonnichsen (1982). As Binford (1981) demonstrated, argument from elimination has logical difficulties (see Bunn [1982], Grayson [1982] and Will [1982]). Such difficulties arise because of the virtual impossibility of listing all the potential causes; it is nearly always possible to find an additional “what if” situation, or one more “working hypothesis.” Of course, some possible answers will be more probable or produce stronger inferences (Platt 1964), but it remains unclear how to evaluate several mutually strong inferences (Willer and Willer 1973).

I suspect that the difficulties in the arguments from elimination and multiple working hypotheses arise, at least in part, from attributes of the phenomena in question. Why else would archaeologists be so ready to accept the identification of a stone object as, for instance, a Clovis-style projectile point? The object has been modified in such a manner that no reasonable combination of conceivable agents other than people could have produced it. Bone objects that have undergone a similar degree of modification are also accepted as artifacts because only people could have produced such a “formalized” (Wheat 1982:169) object. However, when one is dealing with more primitive (my term, see above) objects, displaying less sophistication and/or formalization of modification, such as those from Calico Hills or those labeled “bone expediency tools”—the “possible artifact” category of Haynes (1973a)—neither arguments from elimination nor multiple working hypotheses work well because of the uncontrolled problem of equipfinality.

A POSSIBLE SOLUTION

The bone expediency tool concept is intriguing. It makes sense, and is perhaps a significant insight into the ways in which people may have adapted to and manipulated their environment. Yet, at present, it lacks a firm methodological basis that allows these tools to be regularly and systematically identified, and the validity of such identifications to be rigorously and objectively tested. Similar problems exist with the recognition and identification of some “primitive” stone tools (see Patterson [1983] and references therein).

The issue of identification of bone expediency tools might be refocused by developing reasonable expectations concerning how such tools should “behave” in the archaeological record. Refocusing analytic techniques from a technological or use-history perspective (Figure 1) to a functional perspective may circumvent the logical difficulties of identifying these tools using criteria derived from Figure 1. Frison (1982) has, for example, noted that bone choppers do not always occur in the same relative abundance and in the same sites as toothed fleshers that are made from bones. He suggests that this may reflect cultural or ethnic differences, or it may reflect differences in the availability of raw materials for tool manufacturing. The second alternative seems unlikely to me, particularly at kill sites where all the bony elements of the skeleton are at least initially present and available. While an explanation based upon cultural or ethnic differences may be accurate, an equally likely (if not more probable) explanation is that the differences in “bone expediency tool” assemblages between sites result from different contingencies which affect particular episodes of butchering (e.g., Binford 1978). Choppers may be used more frequently in the winter and fleshers in the summer; such contingencies have yet to be systematically considered.

The potential morphological variability of bone expediency tools is limited by the finite number of shapes of skeletal elements. Further, some tools are broken and the represented skeletal element cannot be determined. Stone tools are not always classified according to the type of stone from which they are made, and I suspect that we need not consider the type of bone from which a bone expediency tool is made, at least initially, because the purpose of the classification I outline is to detect functional differences, not technological differences (see papers in Whallon and Brown [1982]). I recommend that classification of bone objects suspected to be “bone expediency tools” be based on both the type and distribution of UWM (see Sadek-Kooros [1975] for an initial attempt).
suggestion is consistent with that offered several years ago by Myers et al. (1980). This approach assumes that different tasks will produce different wear patterns; therefore, if bone expediency tools were used for varied tasks, UWM patterns should vary between sites. It is well documented that butchery is a highly variable and contingency-bound activity (Binford 1978; Frison 1978), and such diverse contingencies will result in different frequencies and types of particular classes of UWM between sites. Expectations may be formulated concerning variations in UWM patterns on bone expediency tools from site to site, from situation to situation, and butchery task to butchery task. This kind of approach has been applied with some success to UWM patterns on lithic tools (e.g., Dunnell 1978), and may prove equally successful in studies of bone tools. The approach will at least provide an independent test of identifications of “bone expediency tools” based on the conjectural use-history.

There are two potential difficulties in analyses of UWM patterns on bone tools. First, only small samples of bone tools are recovered from many sites. Variations in UWM patterns between sites must be demonstrably attributable to factors other than sample sizes. There are statistical techniques for assessing the effects of sample sizes on archaeofaunal data (Grayson 1981) which might be adapted to bone tool analysis. The second difficulty is that various natural agencies and processes can produce modifications not unlike UWM patterns. It is becoming apparent, however, that carnivores (e.g., Haynes 1980, 1982) and other natural agents and processes (e.g., Haynes 1983; Shipman and Rose 1983) modify bones in particular ways that result in patterns that are different from UWM patterns. While equifinality is becoming better controlled in this case, it is still not under complete control. Nonetheless, the patterns of modification created naturally can be used as a guide to the reasonableness of postulated “behaviors” of UWM patterns. Further, such naturally created patterns of modification should occur in ways that are different from those of UWM patterns in the archaeological and fossil records. When the patterns of modification observed in the archaeological record conform to our expectations for UWM patterns, and when the observed patterns occur differently from what is expected of naturally created modification patterns, a strong inference can be made that the objects under scrutiny are tools.

While I have perhaps been overly critical in my remarks, I tend to agree with Bell (1982) that “criticizable explanations” are one strong point of our discipline. Weaknesses in explanations, when pinpointed, will motivate a search for alternatives and, ultimately, the design of better explanations. Our explanations should be testable and refutable in the empirical realm. To enhance these characteristics of our explanations, we should not only clarify the problems we wish to solve, but construct methods for solving these problems in such a manner as to allow their evaluation and improvement. It was with these thoughts in mind that I wrote this article. I believe there will always be a “gray area” into which can be placed objects which could be tools but may not be tools. Development of methods for explaining and correctly identifying such objects in order to reduce the population of the “gray area” will prove to be challenging, but not, I suspect, impossible if our methods are regularly and consistently evaluated.

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